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CARPENTRY and BUILDING

A Complete Manual of Carpentry and Joinery,
Covering Every Known Detail of the Trade.

Designed to Afford Practical Help in the
Every-Day Problems of the Car-
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the Architect

Arranged and Edited by
FRED T. HODGSON
Architect

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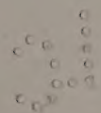
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PREFACE

As Editor of one of the most popular building journals in the United States (*"The National Builder"*), I have frequently been asked by readers of that journal, "if there were any books recently published in America devoted entirely to the science of heavy and light timber framing?" In every case I have been compelled to answer these queries in the negative, but in all cases I made it a point to inform my correspondents of the existence of such works as "Bell's Carpenter," published in 1857, "Hatfield's American Carpenter," published in 1880, and of the excellent work published in England under the authorship of Prof. Tredgold, and I also advised them of the current articles that were running through the pages of *"Carpentry and Building," "Architecture and Building," "The Builder and Woodworkers," "The California Architect"* and *"The National Builder,"* all of which papers contained a number of excellent treatises on *Balloon Framing*, and the framing of heavy timber; and in many cases, one or the other of these treatises sufficed to satisfy the requirements of the querist. Many readers, however, were not satisfied; they wanted

something more comprehensive and more compact—something where they would not be compelled to wade through volume after volume to find the material they wanted—and in order to meet this condition I have made this present endeavor to collect together, and put in a handy form, most of the good and useful articles on framing and timber construction that would now be difficult to find by the workman of the present day; and the work herewith presented to my readers is largely made up of matter that has appeared in some form or other, in the books mentioned in the foregoing, or in the journals named, all of which have been thoroughly overhauled and put in such an up-to-date shape, as will suit the requirements of present day conditions.

“Is heavy timber framing a lost art?” is a question that has been asked dozens of times during these few years by hundreds of young workmen—and old workmen, too—in the South and West, and particularly in the Pacific Coast States, and Northwest Canada. The art of heavy timber framing is not lost by any means, for there yet remains in some of the New England States, and in New York, Pennsylvania, Michigan, Wisconsin and many other of the Western, Southern, and Middle States, hundreds of old framers who are capable of taking the timber from the stump, hewing, counter-hewing, and framing it into bridges, trestle-work, mills, factories, barns and houses, or

into any other structure that may be required. If there was a demand for such skilled workmen, I feel assured the men would soon be on hand—providing of course a suitable compensation was offered for their services.

In the larger towns and cities, the introduction of steel structural work has in a great measure superseded the use of heavy timber work in buildings of any pretensions. Floors, roofs, bridges, trusses, and all such similar work, are now made of steel, thus displacing timber. Without entering into a discussion on the merits of steel, or claiming for it any superiority over our old timber friends, it is easy to see that steel structural work has come to stay, and though it may be many a long year before its free use will make much headway in localities where timber is cheap and plentiful, it will in the end crowd out the extensive use of timber for structural purposes.

While the main object of this book is to give instruction in framing, it will also be within its purview to illustrate and describe designs in timber-work of all kinds, including roofs, domes, framed walls, bridges, towers, centers, spires, and other similar work, and in order to be able to deal with these works in an intelligent and efficient manner, I think it wise to give, as an introductory chapter, a short treatise on joints in woodwork, with an explanation of their uses and qualifications for the work for which they are intended. In

doing this I cannot do better than follow Henry Adams, C. E., who years ago gathered together nearly all the joints known and published them in one paper along with descriptions of same, most of which I embody in the present work. The illustrations showing these joints are taken from the older works of Batty Langley, Paine, Moxen, Nicholson, Tredgold, Barlowe, Robert Burn Scott, Hatfield and others, where they were scattered among other illustrations of various kinds of woodwork.

These joints, as illustrated in this work, are applicable to either balloon or scantling framing or to the framing of heavy timber, and for almost any kind, style, or shape of work, so that the workman will find, in some one of the examples shown, something suitable for the work in hand.

The examples of balloon framing shown are of the latest and most approved designs, such as experience has proven to be the best for the purposes to which they are applied, and I am sure those of my readers who have not had a training in balloon framing, will have but little difficulty in following them in actual work, and the older hands who have worked for years on balloon work will also find many things in this book that will be of advantage to them in many ways.

With regard to heavy timber framing I have endeavored to follow the best known methods, to which I have added something gained by an ex-

perience of over thirty years in the designing, superintendence, and building of heavy structures in wood, both in Canada and the United States. Forty years ago, when timber framing was in "flower" and grain elevators were built of timber, I had considerable experience in that line, and in other railway structures and similar work, and have ever since, in connection with my business, been kept in touch with timber framing of more or less magnitude, and this experience, along with the book knowledge I have gathered together, leads me to think I can place before my readers the subjects under consideration in a clearer and better light, than they have ever before been rendered. At any rate, I venture to launch this little book on the same sea of public opinion that has always received my books heretofore in an appreciative spirit, and if it meets with the same favor as my other writings and compilations, neither myself nor my publishers will have any cause for complaint.

FRED T. HODGSON, F. A. I. C.

INTRODUCTORY

JOINTS IN WOODWORK FRAMING.

The joints shown in the following illustrations are such as are mostly employed in framed woodwork, and although they do not cover the whole ground, or show all the styles and methods of framing known to the expert workman, they include nearly all of the principal joints in general use, both in light and heavy framing; later on I may show other joints and splices that are not included in the figures shown in this portion of the work.

The introduction of steel in the construction of buildings has in a great measure displaced woodwork in the erection of large buildings in towns and cities, yet timber working is still of sufficient importance to warrant a careful study of the properties of wood and its uses, hence the following descriptions of various woods are offered in order that the worker may have a more or less intelligent idea of the nature of the materials he is manipulating.

This short treatise it is hoped will be found useful, interesting and instructive to the reader, and while it is not intended to be exhaustive, it

may be depended upon to be reliable as far as it goes.

All trees are divided by botanists into three classes; Exogens, or outward-growers; Endogens, or inward-growers; and Ecrogens, or summit growers—according to the relative position in which the new material for increasing the substance of the tree is added; viz., whether towards the outside, the inside or the top. Typical trees of each class would be the oak, the palm, and the tree fern. We have to deal with the exogenous class only, as that furnishes the timber in general use for construction, the term “timber” including all varieties of wood which, when felled and seasoned, are suitable for building purposes.

If the stem of an exogenous tree be cut across, it will be found to exhibit a number of nearly concentric rings, more or less distinct; and, in certain cases, radial lines intersecting them. These rings represent the annual growth of the tree which takes place just under the bark. Each ring consists of bundles of woody fibre or vascular tissue, in the form of long tapering tubes, interlaced and breaking joint with each other, having a small portion of cellular tissue at intervals. Towards the outer edge of each ring the woody fibre is harder, more compact, and of a darker color than the remaining portion. The radial lines consist of thin, hard, vertical plates formed entirely of cellular tissue, known to botanists as “Medullary

rays'' and to carpenters as ''silver grain.'' Fig. 1 shows the woody fibre as seen in a magnified vertical section, Fig. 2 the cellular tissue and Fig. 3 a typical section of the stem of a young tree, *a* being the woody fibre, *b* the pith, *c* the medullary rays, and *d* the bark; the three latter consisting

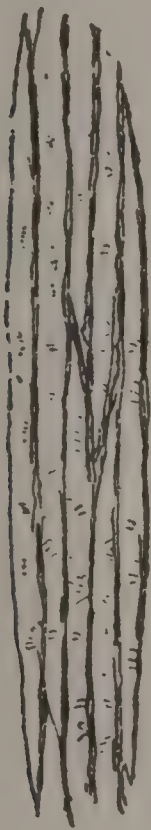


Fig. 1.

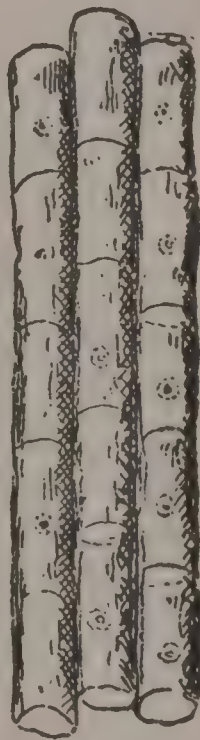


Fig. 2.

of cellular tissue and enclosing the woody fibre in wedge-shaped portions. As the tree advances in age, the rings and rays become more irregular, the growth being more vigorous on the sunny side, causing distortion. The strength of wood ''along the grain'' depends on the tenacity of the walls

of the fibres and cells, while the strength “across the grain” depends on the adhesion of the sides of the tubes and cells to each other.

Tredgold proposed a classification of timber according to its mechanical structure, this, as modified by Professor Rankine which is given in the following table, also by Trantwine and others.

Class I. Pine-wood (coniferous trees)—pine, fir, larch, cowrie, yew, cedar, etc.

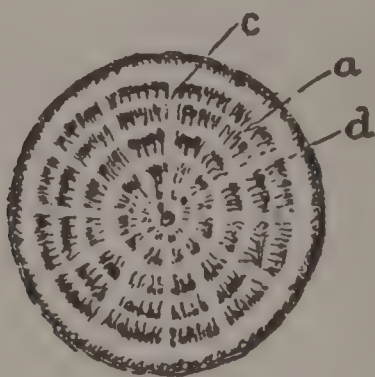


Fig. 3.

Class II. Leaf-wood (non-coniferous trees),
Division I with distinct large medullary rays.

Sub-division I. Annual rings distinct—oak.

Sub-division II. Annual rings indistinct, beech, birch, maple, sycamore, etc.

Division II. No distinct large medullary rays.

Sub-division I. Annual rings distinct—chestnut, ash, elm, etc.

Sub-division II. Annual rings indistinct—mahogany, teak, walnut, box, etc.

Knowing now the microscopical structure of the wood, we are in a position to understand the

process of seasoning, and the shrinking incidental to that operation. While wood is in a growing state there is a constant passage of sap, or nutritive fluid, which keeps the whole of the interior of the tree moist and the fibres distended, but more especially towards the outside. When the tree is cut down, and exposed to the air, the moisture gradually evaporates, causing the fibres to shrink according to certain laws; this is the natural process of seasoning. There are various methods of seasoning timber artificially, in each case the object in view is to expedite the process of evaporation. The shrinkage in length is very slight, and need not therefore be considered; but the shrinkage transversely is so great that it is necessary to look closely into the nature of it, as the question of jointing is affected considerably thereby.

If Fig. 4 be taken as representing the section of a newly felled tree, it will be seen that the wood is solid throughout, and on comparing Fig. 5 with this the result of the seasoning will be apparent. The action is exaggerated in the diagrams in order to render it more conspicuous. As the moisture evaporates, the bundles of woody fibre shrink and draw closer together; but this contraction cannot take place radially, without crushing or tearing the hard plates forming the medullary rays, which are unaffected in size by the seasoning. These plates are generally sufficiently strong to resist the crushing action, and the contraction is there-

fore compelled to take place in the opposite direction, *i. e.* circumferentially, the strain finding relief by splitting the timber in radial lines, allowing the medullary rays in each partially severed portion to approach each other in the same direction

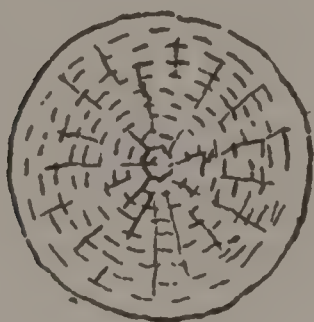


Fig. 4.

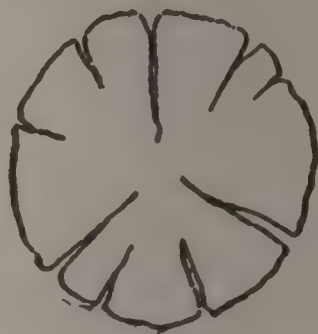


FIG. 5.

as the ribs of a lady's fan when closing. The illustration of a closing fan affords the best example of the principle of shrinking during seasoning, every portion of the wood practically retaining

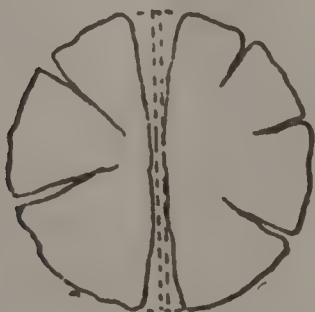


Fig. 6.

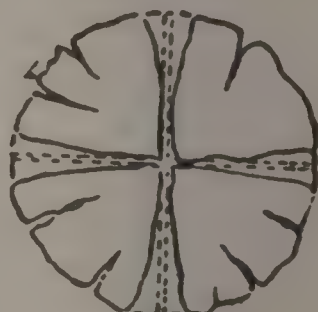


Fig. 7.

its original distance from the center. If the tree were sawn down the middle, the cut surfaces, although flat at first, would in time become rounded, as in Fig. 6, the outer portion shrinking more than that nearer the heart on account of the greater

mass of woody fibre it contains and the larger amount of moisture. If cut into quarters each portion would present a similar result, as shown in Fig. 7. Figs. 8 to 12 show the same principle ap-



Fig. 8.



Fig. 9.

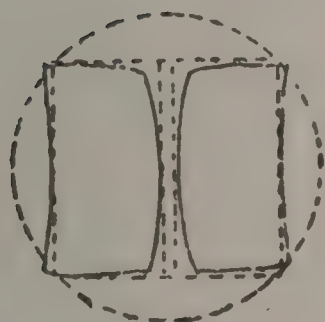


Fig. 10.

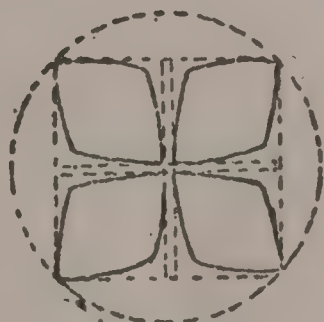


Fig. 11.



Fig. 12.

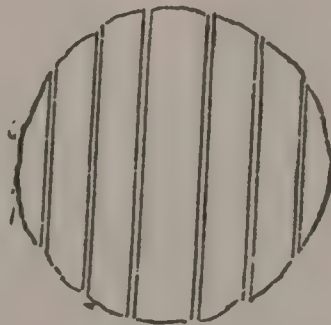


Fig. 13.

plied to sawn timber of various forms, the peculiarities of which are perhaps indicated more clearly in Fig. 14. If we assume the tree to be cut into planks, as shown in Fig. 13, it will be found, after

allowing due time for seasoning, that the planks have altered their shape, as in Fig. 14. Taking the center plank first, it will be observed that the thickness at the middle remains unaltered, at the edge it is reduced, and both sides are rounded, while the

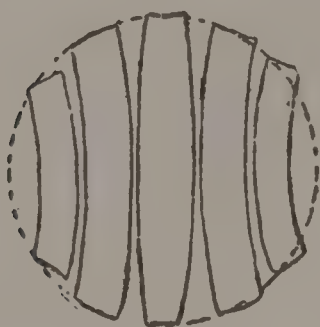


Fig. 14.



Fig. 15.

width remains unaltered. The planks on each side of this are rounding on the heart side, hollow on the other, retain their middle thickness, but are reduced in width in proportion to their distance

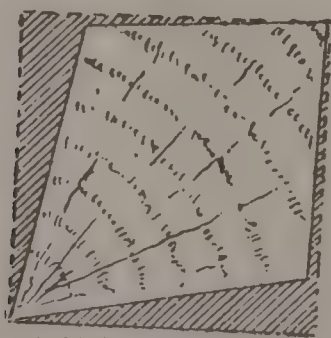


Fig. 16.

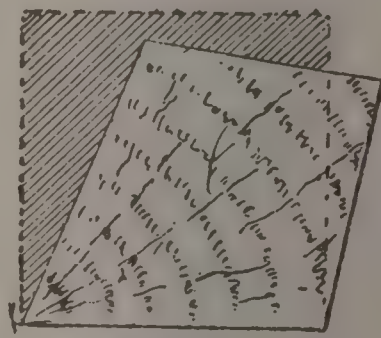


Fig. 17.

from the center of the tree; or, in other words, the more nearly the annual rings are parallel to the sides of the planks the greater will be the reduction in width. The most striking result of the shrinkage is shown in Figs. 15-17. Fig. 15

shows a piece of quartering freshly cut from unseasoned timber; in Fig. 16 the part colored black shows the portion lost by shrinkage, and Fig. 17 shows the final result. These remarks apply more especially to oak, beech and the stronger firs. In the softer woods the medullary rays are more yielding, and this slightly modifies the result; but the same principles must be borne in mind if we wish to avoid the evils of shrinking which may occur from negligence in this respect.

The peculiar direction which "shakes," or natural fractures, sometimes take is due to the unequal adhesion of the woody fibres, the weakest part yielding first. In a "cup shake," which is the separation of a portion of two annual rings, the medullary rays are deficient in cohesion. This same fault sometimes occurs in white pine and has been attributed to the action of lightning and of severe frosts. So far we have considered the shrinking only as regards the cross section of various pieces. Turning now to the effect produced when we look at the timber in the other direction, Fig. 18 represents a piece of timber with the end cut off square; as this shrinks, the end remains square, the width alone being affected. If, however, the end be bevelled as in Fig. 19 we shall find that in shrinking it assumes a more acute angle, and this should be remembered in framing roofs, arranging the joints for struts, etc., especially by the carpenters who have to do actual

work of fitting the parts. If the angle be an internal one or bird's mouth, it will in the same way become more acute in seasoning. The transverse shrinkage is here considered to the exclusion of any slight longitudinal alteration which might occur, and which would never be sufficient to affect the angle of the bevel. When seasoned timber is used in position subject to damp, the wood will swell in exactly the reverse direction to the shrinkage, and induce similar difficulties unless this point has also received due attention. Of course it will be seen from a study of the cross sections

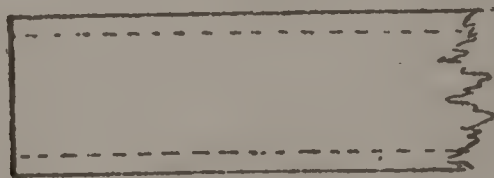


Fig. 18.

illustrated in the diagrams that the pieces might be selected in such a way that the shrinkage and expansion would take place chiefly in the thickness instead of the width, and thus leave the bevel unaltered. In this consists the chief art of selecting pieces for framing; but in many instances motives of economy unfortunately favor the use of pieces on stock, without reference to their suitability for the purpose required.

We may now leave the question of shrinkage, and proceed to a consideration of the more immediate intention of the book. In the following

table, which shows the English method of classification, an attempt has been made to place timber under the different terms by which it is known, according to its size, and other accidental characteristics. This is only a rough approximation, as no definite rule can be laid down; but it may be of some assistance to those who have occasionally to deal with workmen using the terms.

CLASSIFICATION OF TIMBER ACCORDING
TO SIZE
(APPROXIMATE)

Baulk.....	12" x 12" to 18" x 18"
Whole Timber.....	9 x 9 to 15 x 15
Half Timber.....	9 x 4½ to 18 x 9
Scantling	6 x 4 to 12 x 12
Quartering	2 x 2 to 6 x 6
Planks.....	11 to 18 x 3 to 6
Joists	2 to 4½
Battens	4½ to 7 x ¾ to 3
Strips and Laths.....	2 to 4½ x ½ to 1½

Pieces larger than planks are generally called timber, but when sawn all round, are called scant-

ling, and when sawn to equal dimensions each way, are called die-square. The dimensions (width and thickness) of parts in a framing are sometimes called the scantlings of the pieces. The term "cut stuff" is also used to distinguish wood in the state ready for the joiner, from "timber" which is wood prepared for the use of the carpenter. A "log" or "stick" is a rough whole timber unsawn.

The use of wood may be discussed under the two heads of carpentry and joinery. The former con-



Fig. 19.

sists principally of the use of large timbers, either rough, adzed, or sawn, and the latter of smaller pieces, always sawn, and with the exposed surfaces planed. The carpenters' work is chiefly outdoor; it embraces such objects as building timber bridges and gables, framing roofs and floors, constructing centering, and other heavy or rough work. Joiners' work is mostly indoor; it includes laying flooring, making and fixing doors, window sashes, frames, linings, partitions, and internal fittings generally. In all cases the proper connection of the parts is an essential element, and

in designing or executing joints and fastenings in woodwork, the following principles, laid down by Professor Tredgold should be adhered to viz.:—

1st. To cut the joints and arrange the fastenings so as to weaken the pieces of timber that they connect as little as possible.

2nd. To place each abutting surface in a joint as nearly as possible perpendicular to the pressure which it has to transmit.

3rd. To proportion the area of each surface to the pressure which it has to bear, so that the timber may be safe against injury under the heaviest load which occurs in practice and to form and fit every pair of such surfaces accurately in order to distribute the stress uniformly.

4th. To proportion the fastenings so that they may be of equal strength with the pieces which they connect.

5th. To place the fastenings in each piece of timber so that there shall be sufficient resistance to the giving way of the joint by the fastenings shearing or crushing their way through the timber.

To these may be added a 6th principle not less important than the foregoing, viz., To select the simplest forms of joints, and to obtain the smallest possible number of abutments. The reason for this is that the more complicated the joint, or the greater the number of bearing surfaces, the less probability there will be of getting a sound and cheaply made connection. To insure a fair and

equal bearing in a joint which is not quite true, it is usual, after the pieces are put together, to run a saw cut between each bearing surface or abutment, the kerf or width of cut being equal in each case, the bearing is then rendered true. This is often done, for instance, with the shoulders of a tenon or the butting ends of a scarf, when careless workmanship has rendered it necessary. When the visible junction of two pieces is required to be

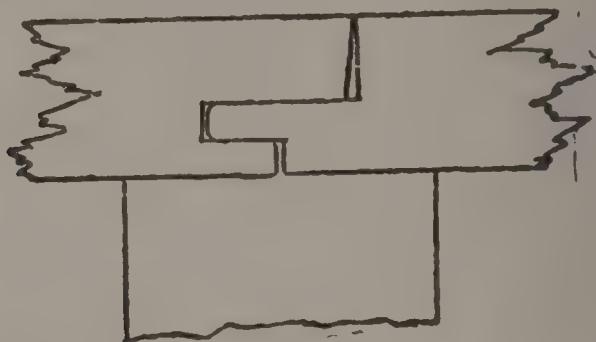


Fig. 20.

as close as possible, and no great strain has to be met at the joint, it is usual to slightly undercut the parts, and give clearance on the inside, as in Fig. 20, which shows an enlarged view of a tongued and rebated heading joint in flooring. In pattern-making the fillets which are placed at the internal angle of two meeting surfaces, are made obtuse angled on the back, in order that when bradded into place the sharp edges may lie close, as shown in Fig. 21. The prints used by pattern-makers for indicating the position of round cored holes are also undercut by being turned slightly hollow on

the bottom, as shown in Fig. 22. The principle is adopted in nearly all cases where a close joint is a desideratum. Clearance must also be left in joints of framing when a settlement is likely to take place, in order that after the settlement, the abutting surfaces may take a fair bearing to resist the strain.

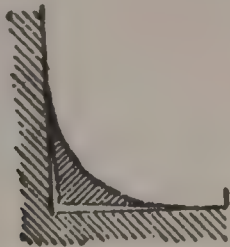


Fig. 21.

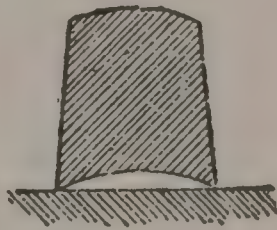


Fig. 22.

The various strains that can come upon any member of a structure are:

Tension: Stretching or pulling,

Compression: Crushing or pushing,

Transverse Strain: Cross strain or bending,

Torsion: Twisting or wrenching,

Shearing: Cutting.

But in woodwork, when the latter force acts along the grain, it is generally called “detrusion,” the term shearing being limited to the action across the grain. The first three varieties are the strains which usually come upon ties, struts, and beams respectively. The transverse strain, it must be observed, is resolvable into tension and compression, the former occurring on the convex side of a loaded beam, and the latter on the concave side, the two being separated by the neutral

axis or line of no strain. The shearing strain occurs principally in beams and is greatest at the point of support, the tendency being to cut the timber through at right angles to the grain; but in nearly all cases if the timber is strong enough to resist the transverse strain it is amply strong for any possible shearing strain which can occur. Keys and other fastenings are especially subject to shearing strain, and it will be shown in that portion of our subject that there are certain precautions to be adopted to obtain the best results.

The following tables will serve as an introduction to this portion of the subject:

CLASSIFICATION OF JOINTS IN CARPENTRY.

Joints for lengthening ties, struts and beams; lapping, fishing, scarfing, tabling, building up.

Bearing-joints for beams; halving, notching, cogging, dovetailing, tusk-tenoning, housing, chase-mortising.

Joints for posts and beams; tenon, joggle, bridle, housing.

Joints for struts with ties and posts; oblique tenon, bridle, toe-joint.

Miscellaneous; butting, mitering, rebating.

CLASSIFICATION OF FASTENINGS IN CARPENTRY.

Wedges,
Keys,
Pins,
Wood pins,

Nails, spikes,
Pins, screws, bolts,
Straps, stirrups, etc.,
Sockets,

And for joinery must be added glue.

We will consider these joints in the order given above. One of the first requirements in the use of timber for engineering purposes is the connection of two or more beams to obtain a greater

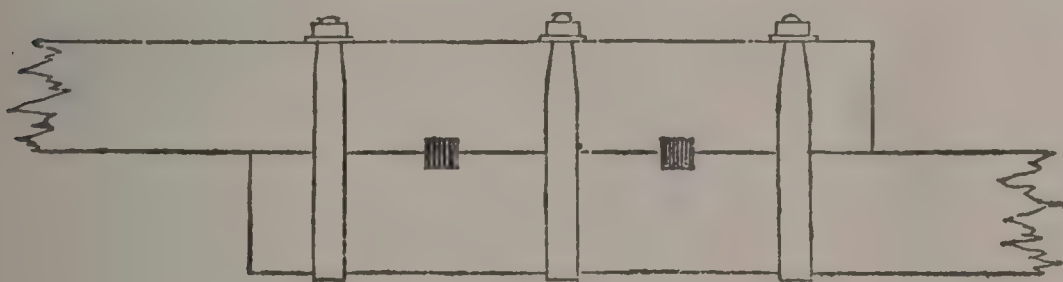


Fig. 23.

length. Fig. 23 shows the method of lengthening a beam by lapping another to it, the two being held together by straps and prevented from sliding by the insertion of keys. Fig. 24 shows a similar joint, through-bolts being used instead of straps, and wrought-iron plates instead of oak keys. This makes a neater joint than the former, but they are both unsightly and whenever adopted

the beams should be arranged in three or five pieces in order that the supports at each end may be level and the beams horizontal. This joint is more suitable for a cross strain than for tension and compression. Fig. 25 shows the common form

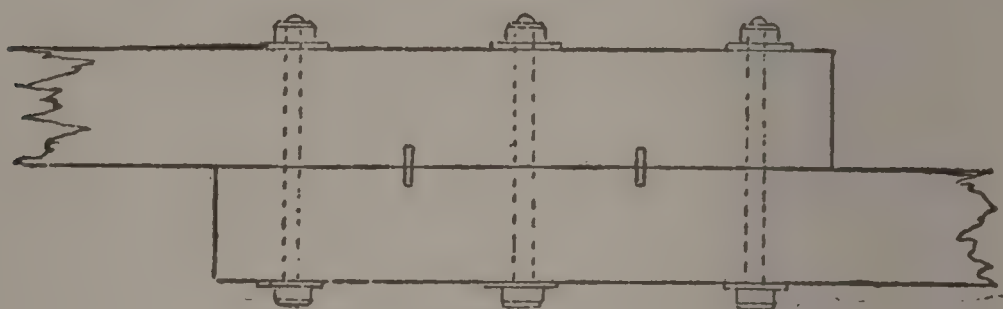


Fig. 24.

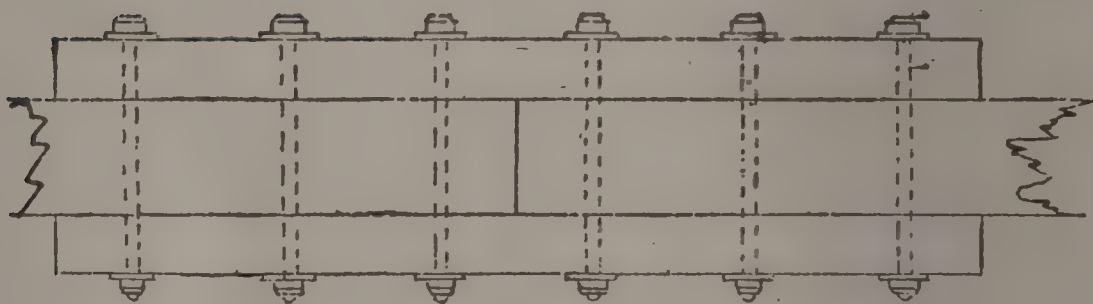


Fig. 25.

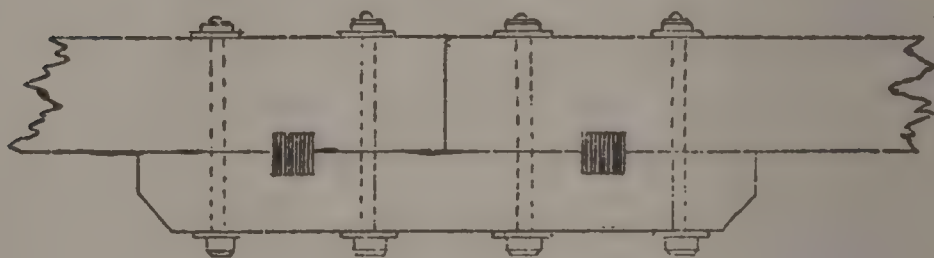


Fig. 26.

of a finished beam adapted for compression. If required to resist tensile strain, keys should be inserted in the top and bottom joints between the bolts. Fig. 26 shows a fished joint adapted for a cross strain, the whole sectional area of the orig-

inal beam taking the compressive portion of the cross strain, and the fishing piece taking the tensile portion. Fig. 27 shows a fished beam for the same purpose in which a wrought-iron plate turned up at the ends takes the tensile strain. Tabling consists of bedding portions of one beam into the other longitudinally. Occasionally the fishing pieces are tabled at the ends into the beams to resist the tendency to slip under strain, but this office is better performed by keys, and in practice tabling is not much used. The distinction between fished beams and scarfed beams is that in the former

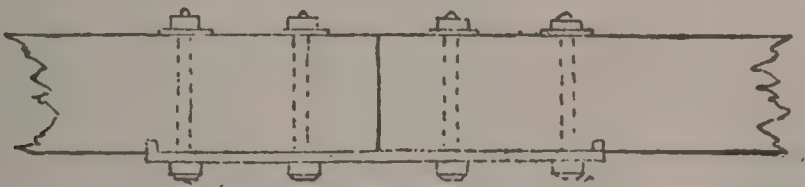


Fig. 27.

the original length is not reduced, the pieces being butted against each other, while in the latter the beams themselves are cut in a special manner and lapped partly over each other; in both cases additional pieces of wood or iron are attached to strengthen the joint. Fig. 28 shows a form of scarf adapted to short posts. Here the scarf is cut square and parallel to the sides, so that the full sectional area is utilized for resisting the compressive strain. When the post is longer and liable to a bending strain the scarf should be inclined, as in Fig. 29, to allow of greater thickness being retained at the shoulder of each piece, the

shoulder being kept square. In this joint a considerable strain may be thrown on the bolts from the sliding tendency of the scarf, if the shoulders should happen to be badly fitted, as any slipping would virtually increase the thickness of the timber where the bolts pass through. The width of each shoulder should be not less than one-fourth the total thickness. Joints in posts are mostly re-

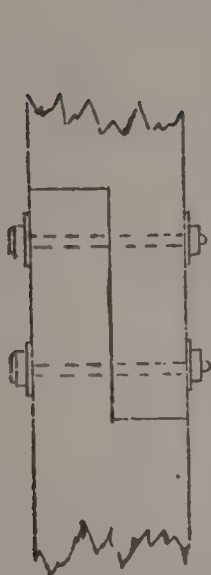


Fig. 28.

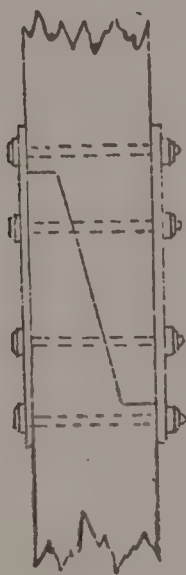


Fig. 29.

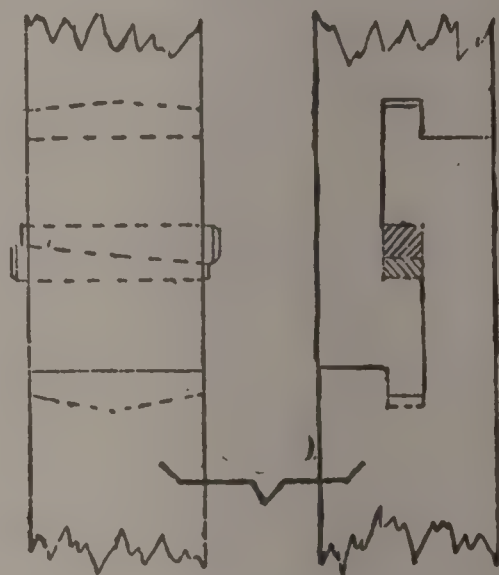


Fig. 30.

quired when it is desired to lengthen piles already driven, to support a superstructure in the manner of columns. Another form of scarf for a post put together without bolts is shown in Fig. 30, the parts being tabled and tongued, and held together by wedges. This is not a satisfactory joint, and is moreover, expensive because of its requiring extra care in fitting; but it may be a suitable joint in some special cases, in which all the sides are re-

quired to be flush. Fig. 31 shows the common form of scarf in a tie-beam. The ends of the scarf are bird's mouthed, and the joint is tightened up by wedges driven from opposite sides. It is further

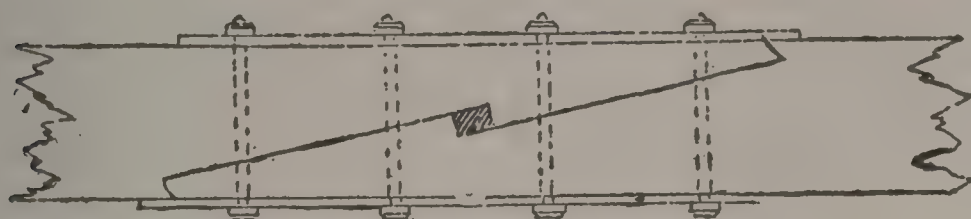


Fig. 31.

secured by the wrought-iron plates on the top and bottom, which are attached to the timber by bolts and nuts. In all these joints the friction between

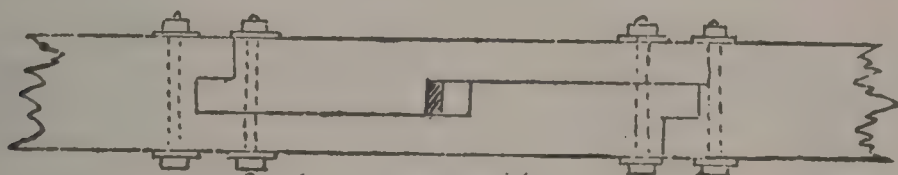


Fig. 32.

the surfaces, due to the bolts being tightly screwed up, plays an important part in the strength of the joint; and as all timber is liable to shrink, it is

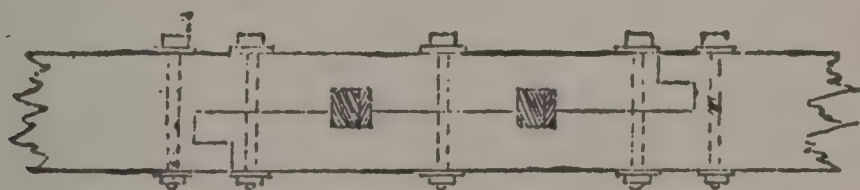


Fig. 33.

necessary to examine the bolts occasionally, and to keep them well tightened up. Figs. 32 and 33 show good forms of scarfs, which are stronger but not so common as the preceding. Sometimes the

scarf is made vertically instead of horizontally, and when this is done a slight modification is made in the position of the projecting tongue, as will be seen from Fig. 34, which shows the joint in ele-

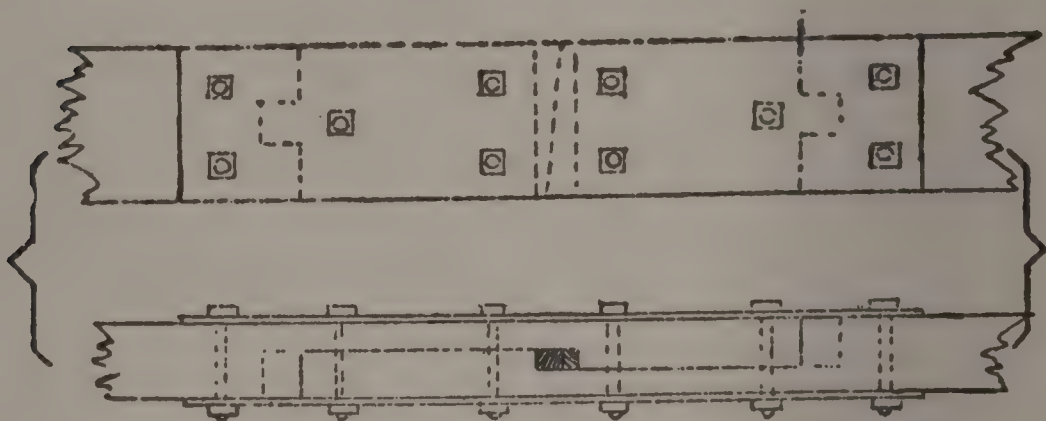


Fig. 34.

vation and plan. The only other scarfs to which attention need be called are those shown in Figs. 35 and 36 in which the compression side is made



Fig. 35.

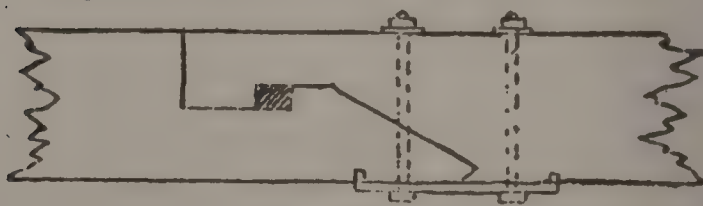


Fig. 36.

with a square abutment. These are very strong forms, and at the same time easily made. Many other forms have been designed, and old books on carpentry teem with scarfs of every conceivable

pattern; but in this, as in many other cases, the simplest thing is the best, as the whole value depends upon the accuracy of the workmanship, and this is rendered excessively difficult with a multiplicity of parts or abutments.

In building up beams to obtain increased strength the most usual method is to lay two together sideways for short spans, as in the lintels over doors and windows, or to cut one down the middle and reverse the halves, inserting a wrought iron plate between, as shown in the fitch-girder,

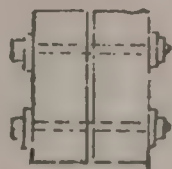


Fig. 37.

Fig. 37. The reversal of the halves gives no additional strength, as many workmen suppose, but it enables one to see if the timber is sound throughout to the heart, and it also allows the pieces to season better. A beam uncut may be decayed in the center, and hence the advantage of cutting and reversing, even if no fitch-plate is to be inserted, defective pieces being then discarded. When very long and strong beams are required, a simple method is to bolt several together so as to break joint with each other, as shown in Fig. 38, taking care that on the tension side the middle of one piece comes in the center of the stand with the two nearest joints equidistant. It is not necessary in a built beam to carry the full depth as far as the supports; the strain is, of course, greatest in the center, and provided there is sufficient depth given at that point, the beam may be reduced towards



Fig. 38.

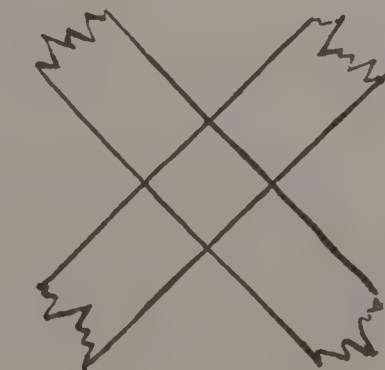


Fig. 40.



Fig. 39.



Fig. 41.



Fig. 42.

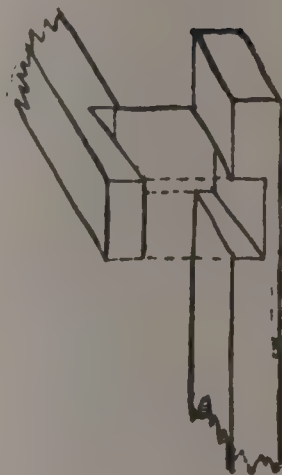


Fig. 44.



Fig. 43.

the ends, allowance being made for the loss of strength at the joints on tension side. A single piece of timber secured to the underside of a beam at the center, as in Fig. 39 is a simple and effective mode of increasing its strength. It will be observed that the straps are bedded into the sides of the beams; they thus form keys to prevent the pieces from slipping on each other. This weakens the timber much less than cutting out the top or bottom, as the strength of a beam varies not only in direct proportion to the breadth, but as the square of the depth. The addition of a second piece of timber in the middle is a method frequently adopted for strengthening shear legs and derrick poles temporarily for lifting heavy weights.

We now come to the consideration of bearing joints for beams, the term "beam" being taken to include all pieces which carry or receive a load across the grain. The simplest of these is the halving joint, shown at Fig. 40, where two pieces of cross bracing are halved together. This joint is also shown at Fig. 41, where the ends of two wall plates meet each other. When a joint occurs in the length of a beam, as at Fig. 42, it is generally called a scarf. In each of these examples it will be seen that half the thickness of each piece is cut away so as to make the joint flush top and bottom. Sometimes the outer end of the upper piece is made thicker, forming a bevelled joint and acting as a dovetail when loaded on top. This is shown

at Figs. 43 and 44. When one beam crosses another at right angles, and is cut on the lower side to fit upon it, the joint is known as single notching, shown in Fig. 45. When both are cut, as in Fig.

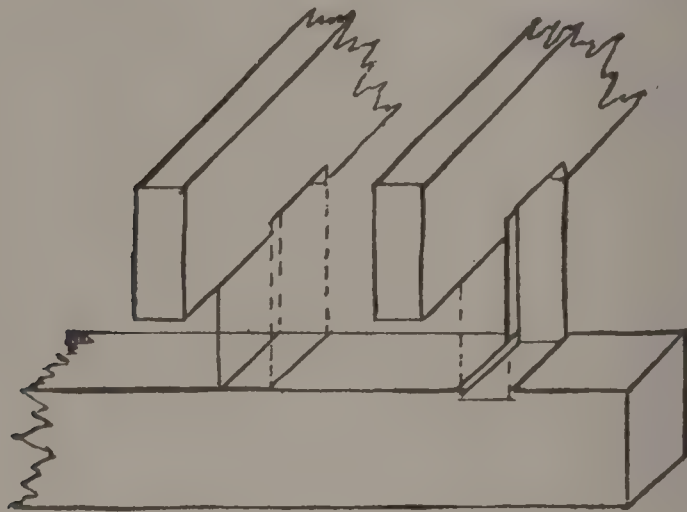


Fig. 45.

Fig. 46.

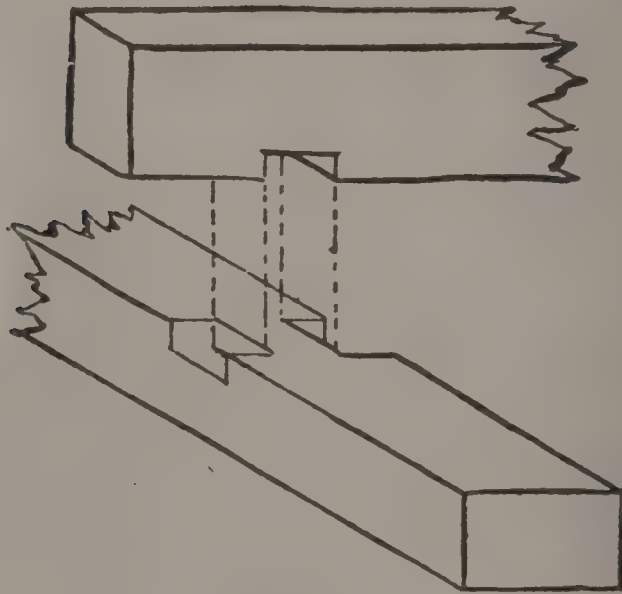


Fig. 47.

46, it is known as double notching. These forms occur in the bridging and ceiling joists shown on the diagrams of double and double-framed flooring. When a cog or solid projecting portion is

left in the lower piece at the middle of the joint it is known as cogging, cocking, or caulking, and is shown in Fig. 47. Figs. 48 and 49 show two forms of the joint occurring between a tie-beam and wall plate in roofing. Dove-tailing is not much

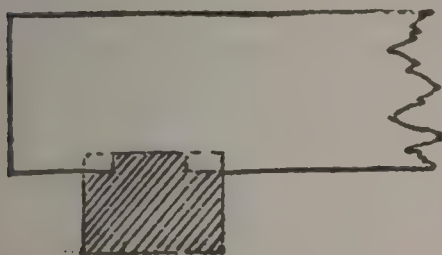


Fig. 48.

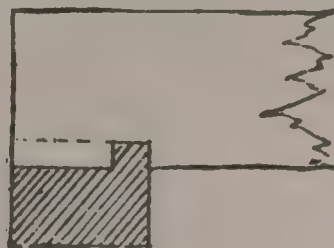


Fig. 49.

used in carpentry or house-joinery, owing to the shrinkage of the wood loosening the joint. Two wall plates are shown dovetailed together at Figs. 50 and 51; in the latter a wedge is sometimes in-

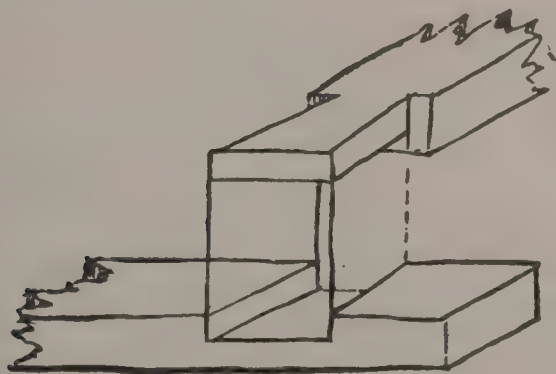


Fig. 50.

serted on the straight side to enable the joint to be tightened up as the wood shrinks. Tredgold proposed the form shown in Fig. 52 which is known as the "Tredgold notch"; but this is never seen in practice. Tusk-tenoning is the method

adopted for obtaining a bearing for one beam meeting another at right angles at the same level. Fig. 53 shows a trimmer supported on a trimming

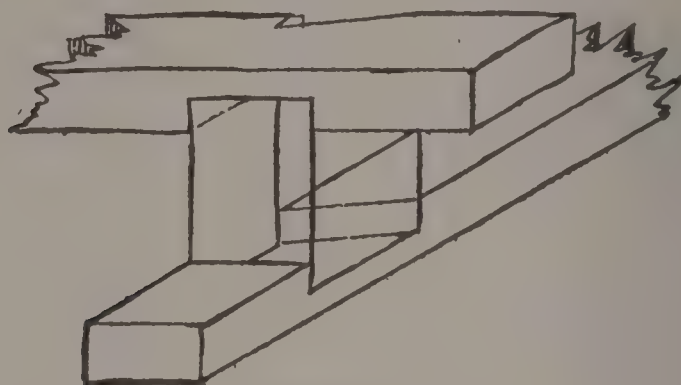


Fig. 51.

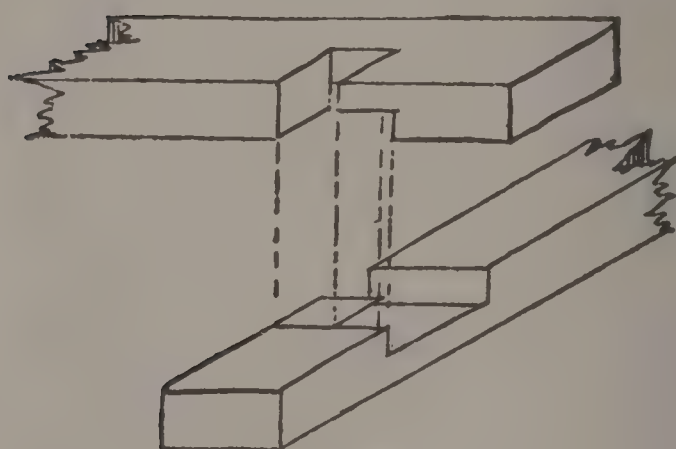


Fig. 52.

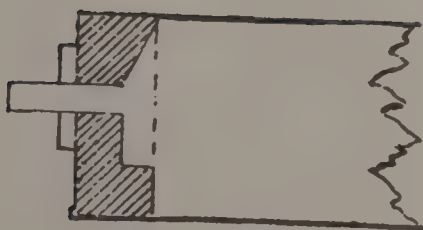


Fig. 53.

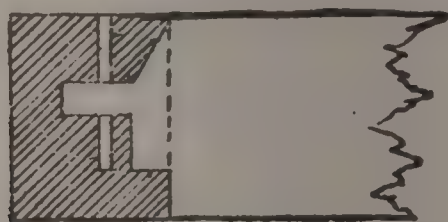


Fig. 54.

joist in this manner; this occurs round fireplaces, hoistways, and other openings through floors. Fig. 54 shows the same joint between a wood girder and binding joist, it is also seen in the diagram of

double-framed flooring. The advantage of this form is that a good bearing is obtained without weakening the beam to any very great extent, as the principal portion of the material removed is taken from the neutral axis, leaving the remainder disposed somewhat after the form of a flanged girder. When a cross piece of timber has to be framed in between two beams already fixed, a tenon and chase-mortise (Fig. 55), is one of the

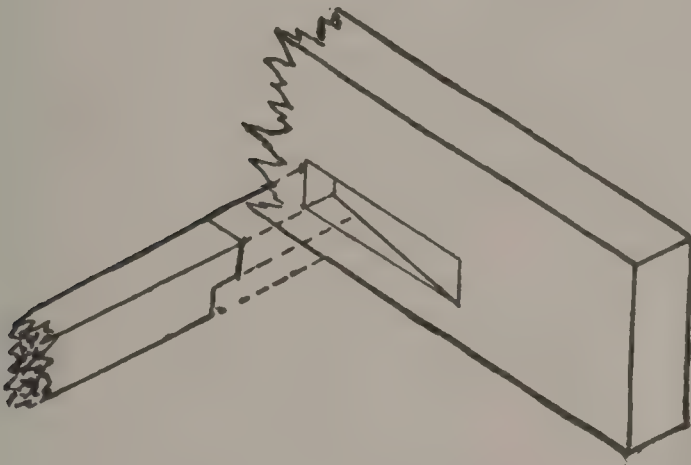


Fig. 55.

methods adopted. If the space is very confined, the same kind of mortise is made in both beams, but in opposite directions; the cross piece is then held obliquely, and slid into place. Occasionally it is necessary to make the chase-mortise vertical, but this is not to be recommended, as the beam is more weakened by so doing—it is shown in Fig. 56. Ceiling joists, fixed by tenons and chase-mortises, are shown on the diagram of double flooring.

In some cases, a square fillet is nailed on, as shown in the same diagram, to take the weight of the joists without cutting into the beam. While speaking of floors, the process of furring-up may be mentioned; this consists of laying thin pieces, or strips, of wood on the top of joists, or any surfaces, to bring them up to a level. Furring-pieces are also sometimes nailed underneath the large beams in framed floors, so that the under side may be level with the bottom of the ceiling joists, to give a

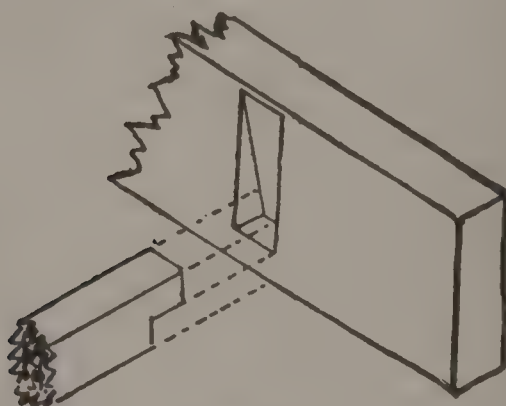


Fig. 56.

bearing for the laths, and at the same time allow sufficient space for the plaster to form a key. Brandering is formed by strips about one inch square, nailed to the under side of the ceiling joists at right angles to them; these strips help to stiffen the ceiling, and being narrower than the ceiling joists, do not interrupt the key of the plastering so much—this is also shown on the diagram of double flooring. Housing consists of letting one piece of wood bodily into another for a short

distance, or, as it were, a tenon the full size of the stuff. This is shown in the diagram of staircase details, where the treads and risers are seen housed into the strings, and held by wedges. Housing is likewise adopted for fixing rails to posts, as in Fig. 57, where an arris rail is shown housed into

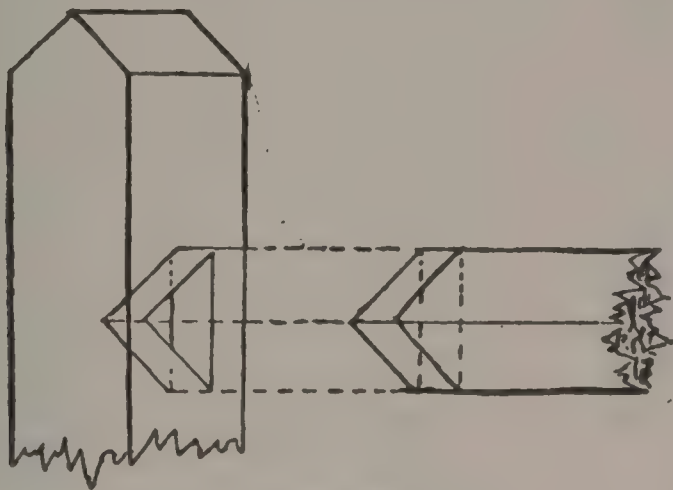


Fig. 57.

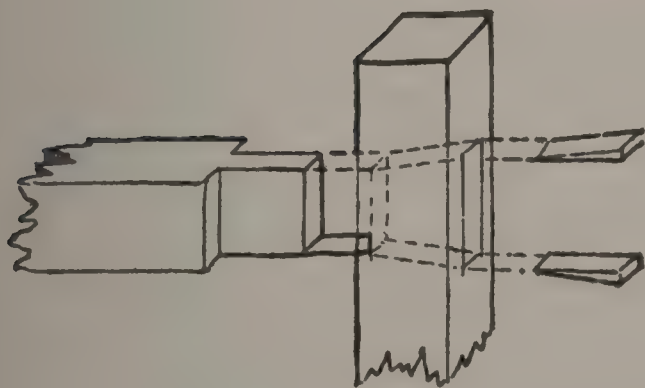


Fig. 58.

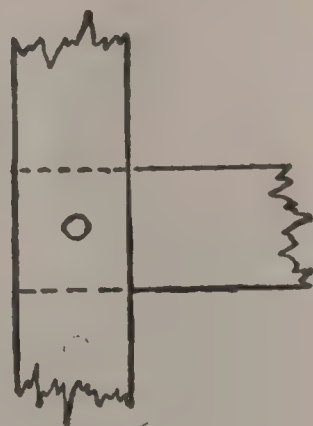


Fig. 59.

an oak post for fencing. The most common joint, however, between posts and beams, is the tenon and mortise joint, either wedged or fixed by a pin; the former arrangement is shown in Fig. 58, and the latter in Fig. 59. The friction of the wedges,

when tightly driven, aided by the adhesion of the glue or white lead with which they are coated, forms, in effect, a solid dovetail, and the fibres being compressed, do not yield further by the shrinking of the wood. In the diagram of a framed door will be seen an example of the application of this joint and in the adjacent diagram will be seen the evils produced by careless fitting, or the use of unseasoned material. When it is desired to tenon a beam into a post, without allowing the tenon to show through, or where a mortise has to be made

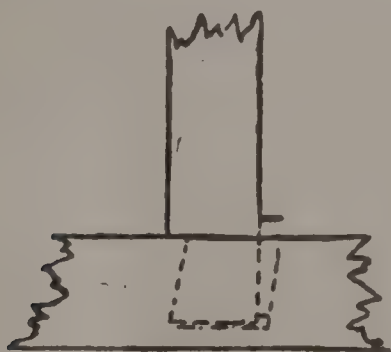


Fig. 60.

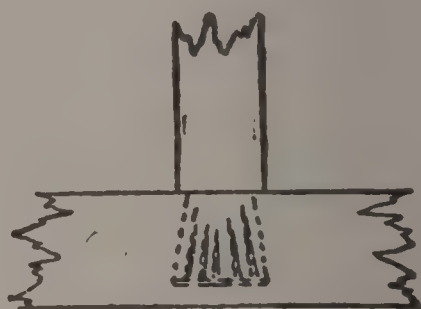


Fig. 61.

in an existing post fixed against a wall, the dovetail tenon, shown in Fig. 60 is sometimes adopted, a wedge being driven in on the straight side to draw the tenon home and keep it in place. In joining small pieces, the foxtail tenon, shown in Fig. 61 has the same advantage as the dovetail tenon, of not showing through; but it is more difficult to fix. The outer wedges are made the longest, and in driving the tenon home, these come into action first, splitting away the sides, and filling up the dovetail mortise, at the same time

compressing the fibres of the tenon. This joint requires no glue, as it cannot draw out; should it work loose at any time, the only way to tighten it up would be to insert a very thin wedge in one end of the mortise. Short tenons, assisted by strap bolts, as shown in Fig. 62 are commonly adopted in connecting large timbers. The post is

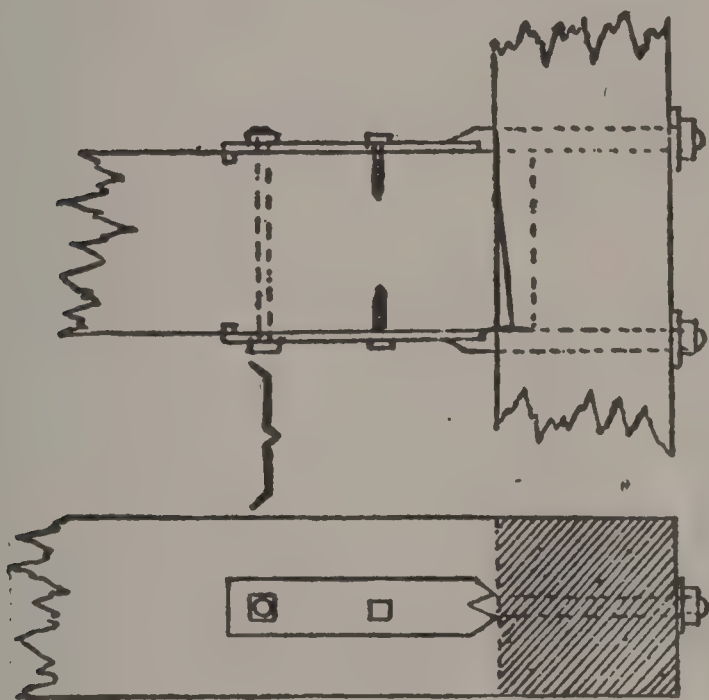


Fig. 62.

cut to form a shoulder so that the beam takes a bearing for its full width, the tenon preventing any side movement. When a post rests on a beam or sill piece, its movement is prevented by a “joggle,” or stub-tenon, as shown in Fig. 63; but too much reliance should not be placed on this tenon, owing to the impossibility of seeing, after the pieces are fixed, whether it has been properly

fitted, and it is particularly liable to decay from moisture settling in the joint. For temporary purposes, posts are commonly secured to heads and sills by dog-irons, or "dogs," Fig. 64; the pieces

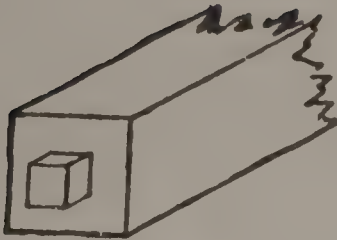


Fig. 63.

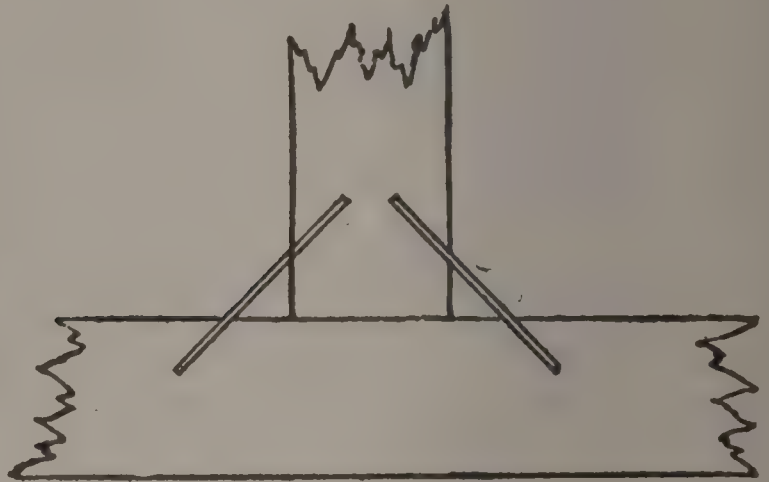


Fig. 64.

in this case simply butt against each other, the object being to avoid cutting the timber, and so depreciating its value, and also for economy of labor. Other forms of tenons are shown in Figs. 65 and 66. The double tenon is used in framing

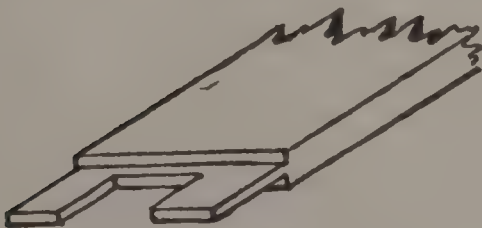


Fig. 65.

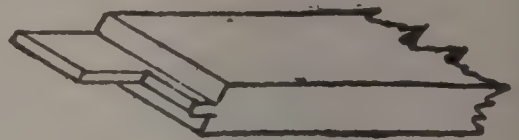


Fig. 66.

wide pieces, and the haunched tenon when the edge of the piece on which the tenon is formed is required to be flush with the end of the piece containing the mortise. Examples of both these will

be found in the diagram of framed door. In Figs. 67 and 68 are shown two forms of bridle joint between a post and a beam. Tredgold and Hatfield recommended a bridle joint with a circular abut-

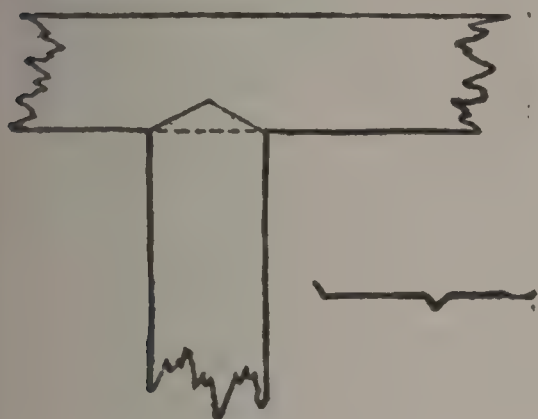


Fig. 67.

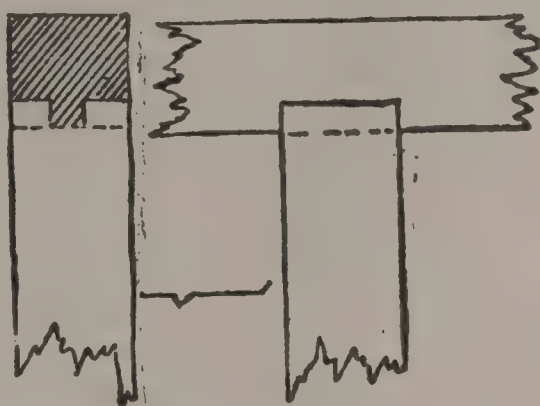


Fig. 68.

ment, but this is not a correct form, as the post is then equivalent to a column with rounded ends, which it is well known is unable in that form to

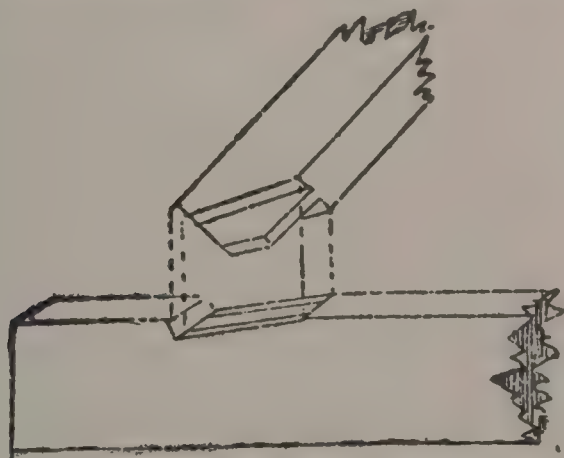


Fig. 69.

bear so great a load before it commences to yield. A strut meeting a tie, as in the case of the foot of a principal rafter in a roof truss, is generally tenoned into the tie by an oblique tenon, as shown in Fig. 69; and the joint is further strengthened

by a toe on the rafter bearing against a shoulder in the tie. Tredgold strongly advised this joint being made with a bridge instead of a tenon, as shown in Fig. 70, on account of the abutting surfaces being fully open to view. A strut meeting a post as in Fig. 71, or a strut meeting the principal rafter of a roof-truss (Fig. 72) is usually connected by a simple toe-joint. The shoulder should be cut square with the piece containing it, or it should bisect the angle formed between the two

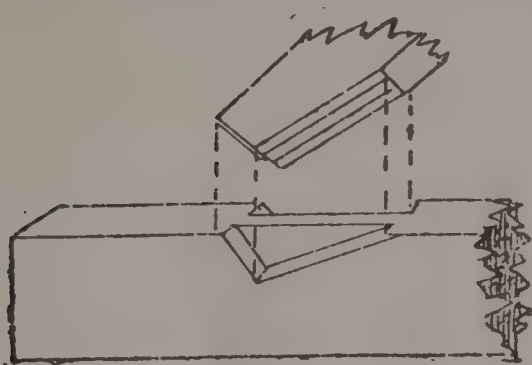


Fig. 70.

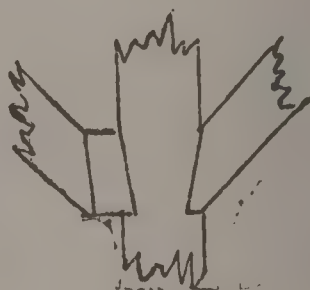


Fig. 71.



Fig. 72.

pieces. It is sometimes made square with the strut, but this is incorrect, as there would in some cases be a possibility of the pieces lipping out. In battened and braced doors or gates this joint is used, the pieces being so arranged as to form triangles, and so prevent the liability to sag or drop, which is so difficult to guard against in square framed work without struts or braces. When a structure is triangulated, its shape remains constant so long as the fastenings are not torn away, because, with a given length of sides, a triangle can assume only one position; but this is not the case with four-

sided framing, as the sides, while remaining constant in length may vary in position. The diagram of a mansard roof shows various examples of a toe-joint; it shows also the principal framing king-post and queen-post roof trusses, each portion being triangulated to insure the utmost stability.

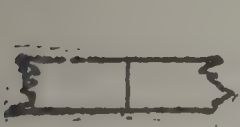


Fig. 73.



Fig. 74.

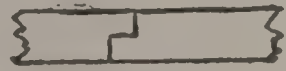


Fig. 75.

Among the miscellaneous joints in carpentry not previously mentioned the most common are the butt joint, Fig. 73, where the pieces meet each other with square ends or sides; the mitre joint, Fig. 74, where the pieces abut against each other with bevelled ends, bisecting the angle between them, as in the case of struts mitered to a corbel piece sup-

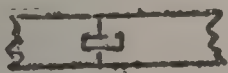


Fig. 76.

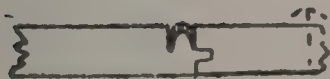


Fig. 77.

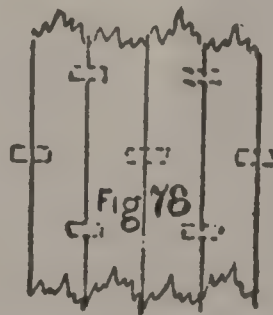


Fig. 78.

porting the beam of a gantry; and the rabbeted or "rebated" joint, Fig. 75, which is a kind of narrow halving, either transverse or longitudinal. To these must be added in joinery the grooved and tongued joint, Fig. 76, the matched and beaded joint, Fig. 77, the dowelled joint, Fig. 78, the dove-

tailed joint, Fig. 79, and other modifications of these to suit special purposes. The application of several of these joints is shown on the various diagrams of flooring, etc. To one of these it may be desirable to call particular attention, viz.: the flooring laid folding. This is a method of obtaining close joints without the use of a cramp. It consists of nailing down two boards and leaving a space between them rather less than the width of, say five boards, these boards are then put in

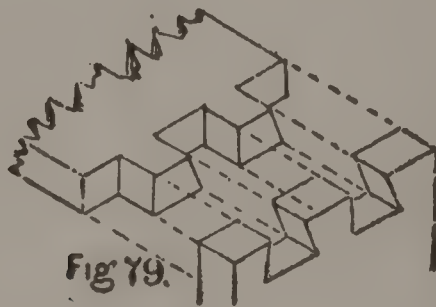


Fig. 79.

place, and the two projecting edges are forced down by laying a plank across them, and standing on it. This may generally be detected in old floors by observing that several heading joints come in one line, as shown on the diagram, instead of breaking joint with each other. It is worthy of notice that the tongue, or slip feather, shown in Fig. 76, which in good work is formed generally of hard wood, is made up of short pieces cut diagonally across the grain of the plank, in order that any movement of the joints may not split the tongue, which would inevitably occur if it were cut longitudinally from the plank.

With regard to fastenings, the figures already given show several applications. Wedges should be split or torn from the log, so that the grain may be continuous, or if sawn out, a straight-grained piece should be selected. Sufficient taper should be put on to give enough compression to the joint, but too much taper would allow the possibility of the wedge working loose. For outside work, wedges should be painted over with white lead before being driven, this not being affected by moisture, as glue would be. In scarf-joints the chief use of wedges is to draw the parts together before the bolt-holes are bored. Keys are nearly parallel strips of hard wood or metal; they are usually made with a slight draft to enable them to fit tightly. If the key is cut lengthwise of the grain, a piece with curled or twisted grain should be selected, but if this cannot be done, the key should be cut crossways of the log from which it is taken, and inserted in the joint with the grain at right angles to the direction of the strain, so that the shearing stress to which the key is subject may act upon it across the fibres. In timber bridges and other large structures cast iron keys are frequently used, as there is with them an absence of all difficulty from shrinkage. Wood pins should be selected in same way as wedges, from straight-grained, hard wood. Square pins are more efficient than round pins, but are not often used, on account of the difficulty of forming square holes for their

reception. Tenons are frequently secured in mortises, as in Fig. 59, by pins, the pins being driven in such a manner as to draw the tenon tightly into the mortise up to its shoulders, and afterwards to hold it there. This is done by boring the hole first through the cheeks of the mortise, then inserting the tenon, marking off the position of the hole, removing the tenon, and boring the pinhole in it rather nearer the shoulders than the mark, so that when the pin is driven it will draw the tenon as above described. This method is called "draw-boring." The dowelled floor shown in Fig. 78 gives another example of the use of pins.

Nails, and their uses, are too well known to need description; it may, however, be well to call attention to the two kinds of cut and wrought nails, the former being sheared or stamped out of plates, and the latter forged out of rods. The cut nails are cheaper, but are rather brittle; they are useful in many kinds of work, as they may be driven without previously boring holes to receive them, being rather blunt pointed and having two parallel sides, which are placed in the direction of the grain of the wood. The wrought nails do not easily break, and are used where it is desired to clench them on the back to draw and hold the wood together. The following table gives the result of some experiments on the adhesion of nails and screws.

ADHESION OF NAILS.

Description of Nails used.	No. to the lb. Avoir.	Inches long.	Inches forced into wood.	Lbs. Pressure to force in.	Lbs. pressure to extract.	
				Dry pine Deal.	Dry Pine Deal.	Dry Elm
Fine brads.....	4560	0.44	.40	—	22	—
"	3200	0.53	.44	—	37	—
Threepenny brads..	618	1.25	.50	—	58	—
Cast-iron nails.....	380	1.00	.25	—	72	—
Sixpenny nails.....	73	2.50	.50	24	—	—
"	"	"	.50	76	—	—
"	"	"	1.00	235	187	327
"	"	"	"	end grain	87	257
"	"	"	1.50	400	327	—
"	"	"	2.00	610	530	—
"	"	"	"	end grain	257	—
Fivepenny nails.....	139	2.00	1.50	—	320	—

French or wire nails have almost driven the cut and wrought nails out of the market. Wire nails, however, are not as lasting as the old fashioned ones, but they are clean, handy to work and can be clinched whenever necessary. They rust quickly, and should not be used for shingling or where damp is likely to get to them.

SUMMARY.

	Across Grain.	With Grain.
Adhesion of nails in Pine....	2	to 1
Adhesion of nails in Elm....	4	to 3

Entrance to extraction is as 6 to 5.

Common screw .2" diam. equals 3 times the adhesive force of a six-penny nail.

Spikes are nearly of the same form as nails, but much larger and are mostly used for heavy timber work. Treenails, so-called, are hard wood pins used in the same way as nails. In particular work, with some woods, such as Oak, they are used to prevent the staining of the wood, which would occur if nails were used and any moisture afterwards reached them. Compressed treenails are largely used in England for fixing railway chairs to sleepers as they swell on exposure to moisture, and then hold more firmly. Screws are used in situations where the parts may afterwards require to be disconnected. They are more useful than nails, as they not only connect the parts, but draw them closer together, and are more secure. For joiner's work the screws usually have counter-sunk heads; where it is desired to conceal them, they are let well into the wood, and the holes plugged with dowels of the same kind of wood, with the grain in the same direction. For carpenters' work the screws are larger and have often

square heads; these are known as coach-screws. The bolts, nuts, and washers used in carpentry may be of the proportions given in the following table:—an example is shown in Fig. 80.

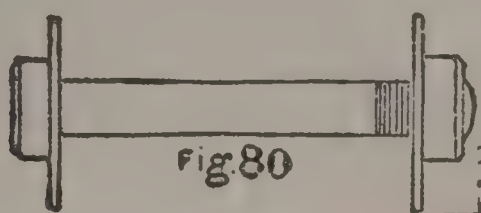


Fig. 80.

Thickness of nut	1 diam. of bolt
Thickness of head	$\frac{3}{4}$ diam. of bolt
Diam. of head or nut over sides.	$1\frac{3}{4}$ diam. of bolt
Side of square washer for fir.	$3\frac{1}{2}$ diam. of bolt
Side of square washer for oak.	$2\frac{1}{2}$ diam. of bolt
Thickness of washer	$\frac{1}{2}$ diam. of bolt

The square nuts used by carpenters are generally much too thin; unless they are equal in thickness to the diameter of the bolt, the full advantage of that diameter cannot be obtained, the strength of any connection being measured by its weakest part. The best proportion for nuts is shown in the diagram of a standard hexagon nut. A large square washer is generally put under the nut to prevent it from sinking into the wood and tearing the fibres while being screwed up, but it is also necessary to put on a similar washer under the head to prevent sinking into the wood. This is, however, often improperly omitted. Straps are

bands of wrought-iron placed over a joint to strengthen it and tie the parts together. When the strap is carried round one piece, and both ends secured to a piece joining it at right angles, as in a king-post and tie-beam, it is known as a stirrup, and is tightened by means of a cotter and gib-keys as shown in Fig. 81. When straps connect more



Fig. 81.

than two pieces of timber together, they are made with a branch leading in the direction of each piece; but they are usually not strong enough at the point of junction, and might often be made shorter than they are without impairing their efficiency. Sockets are generally of cast-iron, and may be described as hollow boxes formed to receive the ends of timber framing.

With regard to the use of glue for securing joints, it has been found that the tensile strength of solid glue is about 4,000 lbs. per square inch, while that of a glued joint in damp weather is from 350 to 360 lbs. per square inch, and in dry weather about 715 lbs. per square inch. The lat-

eral cohesion of pine wood is about 562 lbs. per square inch, and therefore in a good glue joint the solid material will give way before the junction yields.

These joints, though quite numerous, do not exhibit all that are used in carpentry and joinery, but are quite sufficient for our present purpose, as others will be illustrated and described as we proceed.

In balloon or scantling buildings of all kinds, good solid foundations should in every case be provided, for most of the defects often found in frame buildings such as cracks, breaks, sags, etc. are in a great measure due to the settlement of foundation walls, pins, posts or undue shrinkage. When possible, all wood materials such as studding, joists, rafters, collar-beams, trimmers, sills, plates, braces and all other timber or lumber used, should be well seasoned, particularly the joists, as the shrinking of the joists causes the partitions to drop and this makes cracks in the angles of the walls, causes the doors to drag on the floors or to bind at the top and thus disarrange the locks, bolts, catches or other fastenings. Shrinkage of wall studs causes trouble around the windows and outside doors, leaving openings for wind to make its way through into the interior of the house. These things, though apparently of little moment, are quite necessary to be taken into consideration if a good warm and substantial building is desired.

We are now ready to undertake some examples of real work. The first thing to be considered when preparing for a balloon frame after the foundation wall is ready to put on the frame work, is the sill on which the studding is to stand. Of these there are many kinds and I propose to illustrate a selection from which the builder may choose the

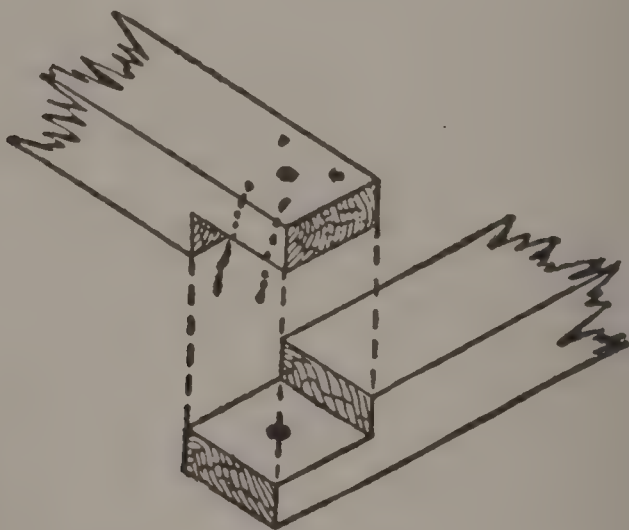


Fig. 82.

one most suitable to his purpose. Fig. 82 is about the most simple of any and is nothing more or less than a 2x4-inch scantling halved at the corner, and may be fastened by a wooden pin or nailed together as shown. A sill of this kind should be laid in mortar and levelled up to take the joists and studding. The joists in this case will rest on the sill altogether, as shown in Fig. 83 or they may be cut or "checked" so as to rest both on stone wall and sill. Fig. 84 shows another method of forming a sill in the old fashioned way. This

makes a good strong sill and secures a warm connection between sill and wall. Another good plan is shown at Fig. 85. Figs. 86, 87, 88, 89, 90 and 91 show a number of various methods of forming sills all of which are good. All sills of this kind should be bedded in mortar and levelled up on their top

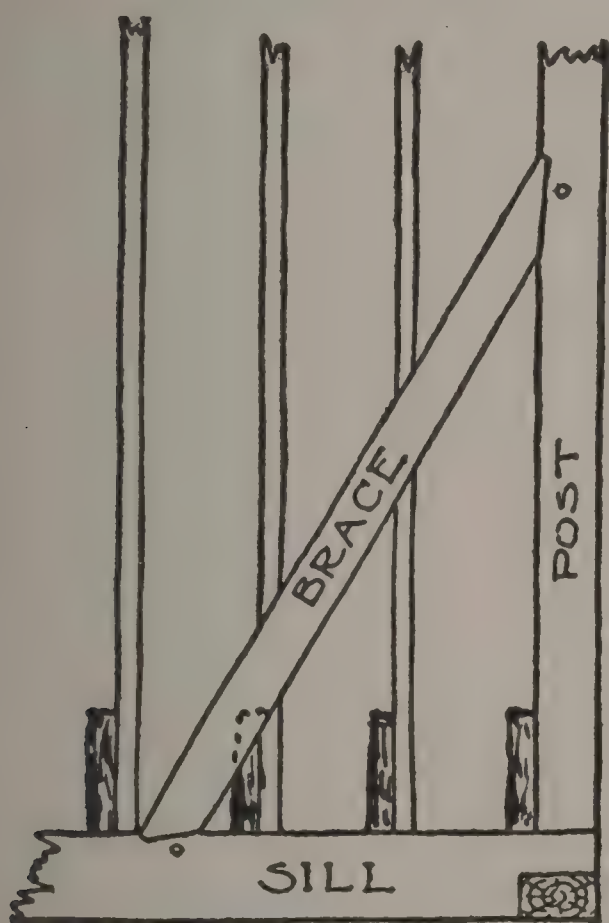


Fig. 83.

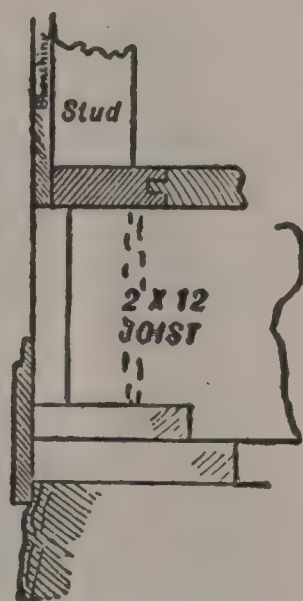


Fig. 84.

flats, and when convenient the spaces between the joists on the wall should be filled in with stone or brick-work level with the top of the upper edges of the joists. By doing this, the building is made more comfortable, stronger, and vermin of all kinds will be prevented from getting into the build-

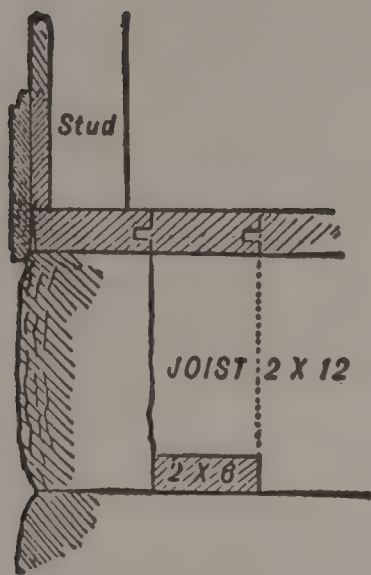


Fig. 85.

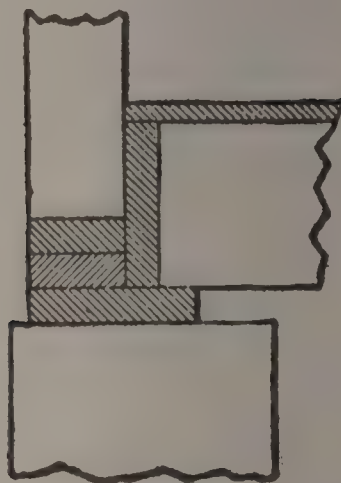


Fig. 86.

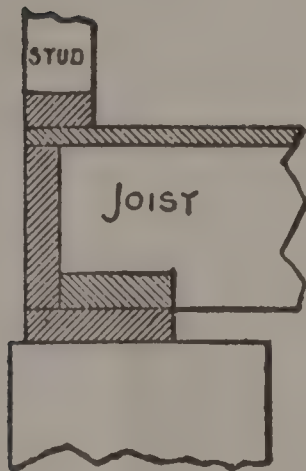


Fig. 87.

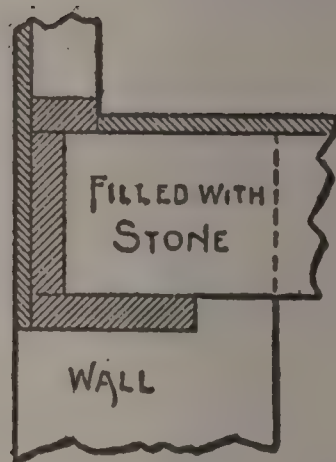


Fig. 88.

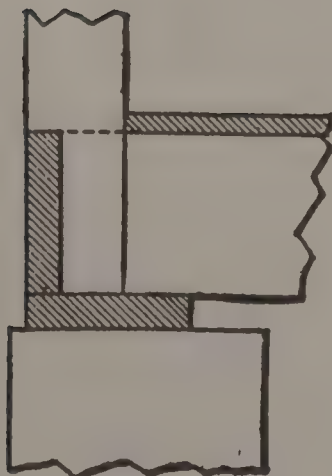


Fig. 89.

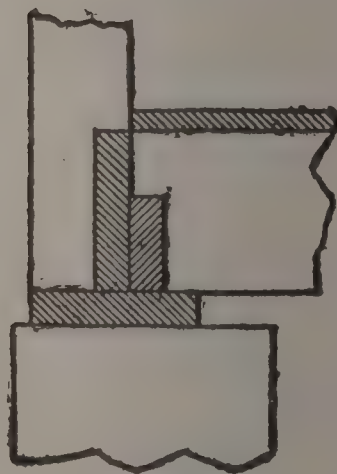


Fig. 90.

ing, and the joists are held together solid in their places. Of course the stone or brick work must be laid in mortar and well flushed up.

Sometimes balloon frames are built up on timber sills of various dimensions and it may be well to give a few examples here of this method, although the matter of framing and laying the sills is simple enough.

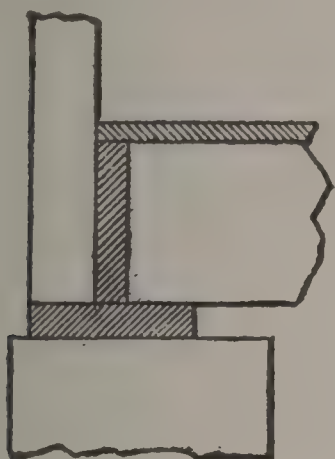


Fig. 91.

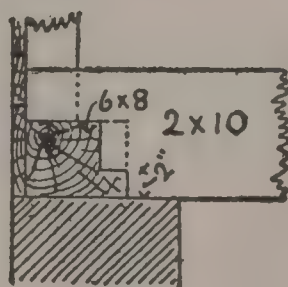


Fig. 92.

Some timber varies in size, often from one-fourth to one-half an inch, and in framing the corners this fact must be noted and provided for or the studs will be too long or too short as the case may be, and the joists will not be in line on top. The sills should be all sized to the same dimension, and all joists should be sized and made equal in width. Fig. 92 exhibits one method of using a timber sill. This is rather a troublesome method and costly, but is really an excellent way as it gives a bearing to the edge of the joists both on the sill

and on the stonework. At Fig. 93 we show another method of using a timber sill. Sometimes, in cases of this kind a tenon is worked on the end of the joists and a corresponding mortise is made in the sill to receive it; more frequently, however, the ends of the joists are nailed to the sill by be-

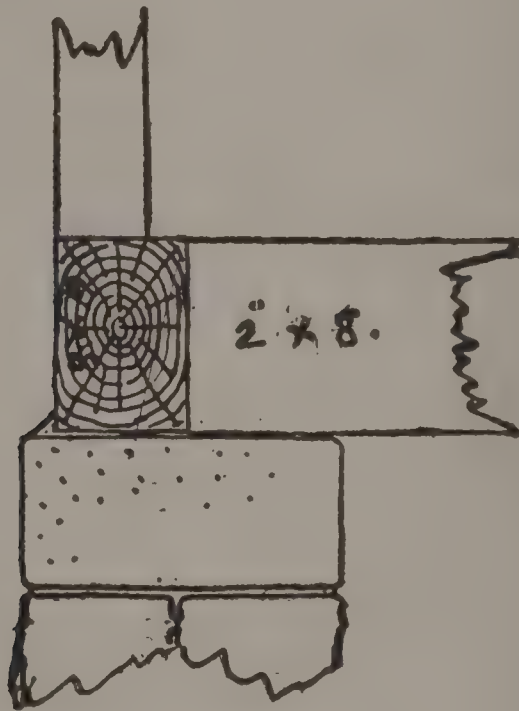


Fig. 93.

ing toe-nailed to it. This method of using a timber sill is not to be recommended, but when it is employed it is always better to cut in boards tight between the joists and nail the boards solid to the sill. This makes a fair job and insures the joists staying in their places. Another method, with a part of the studded wall—in section—is

shown in Fig. 94. This illustration also shows the second and third joists and their manner of attachment to the wall studs. The rafter and scheme for forming the cornice are shown so that the diagram may be followed by the workman without

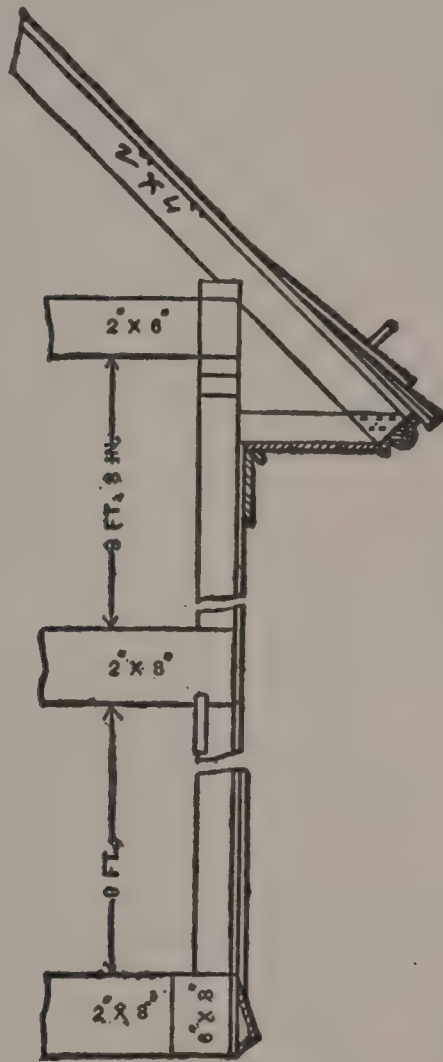


Fig. 94.

trouble. Fig. 95 shows another example of heavy sill with a portion of the wall at the corner and at one side of a window opening. It will be noticed that the corner stud and the jamb stud

and 93, as the joists are apt to split at the corner of the notching if a heavier weight happens to be placed on the floor than was at first intended. The old-fashioned way of framing a heavy sill to receive joists is shown in Fig. 96. This method now is almost obsolete and is only used where joists are to be carried across a large room and

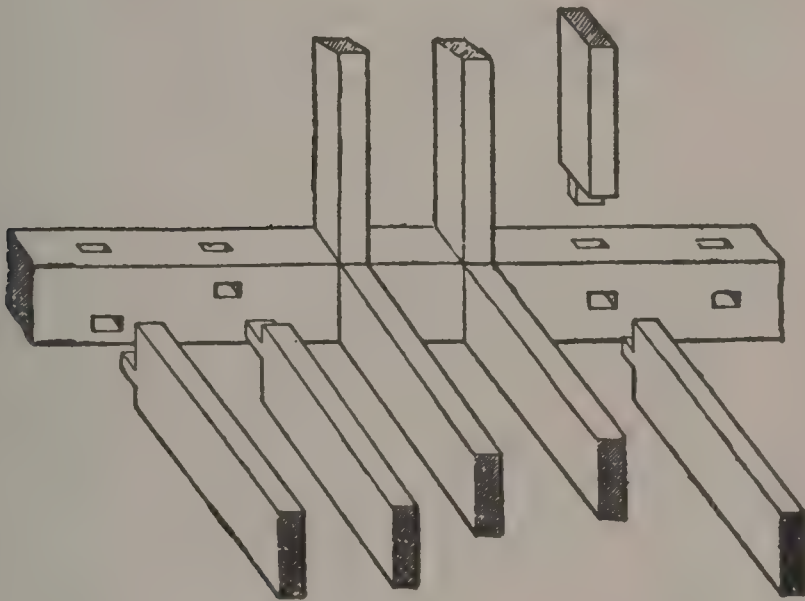


Fig. 96.

where a beam or bearer is not admissible as nothing must show in the room below the ceiling, and where joists are in two lengths. It will be noticed that there are three different methods of framing the joists in the sill. The first shows the mortise too low down on the sill, the second too high up, while the third is in the strongest point where a single tenon and mortise are employed. In the top of the sill the stud mortises are shown, with two

studs *in situ* and one out to show the tenon. There were various methods of framing the joists into the sills in order to obtain the greatest resistance to pressure, among which was the double tenon, the tusk tenon, such as shown in Fig. 97, the upper example being disengaged and the lower one in place. There are also many other methods of framing joists into heavy timber sills, but I have

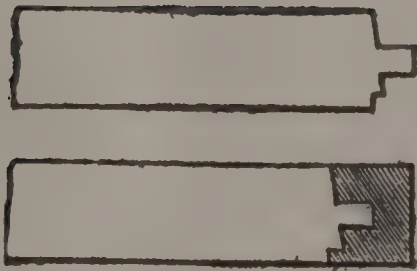


Fig. 97.

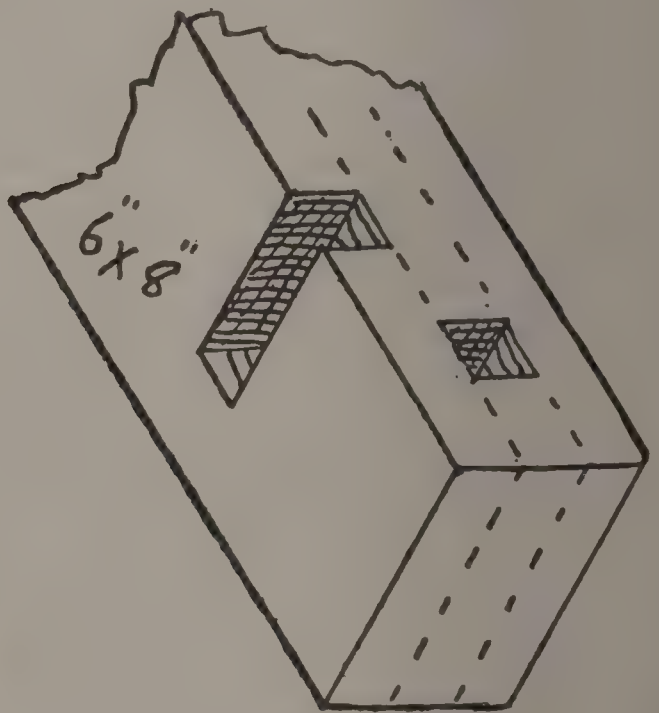


Fig. 98.

exhibited sufficient examples to give an idea of the general methods, and when we get to heavy framing, I will say more on the subject and offer a few extra examples. Fig 98 shows another old-time method of framing a sill. This is called "Gaining and mortising a sill," and was often

put in specifications under this term. Fig. 99 shows a method of forming a sill called a "box sill," as a matter of fact it is no sill at all, being formed of two joists. It is simple, however, and is fairly effective. Another box sill is shown at Fig. 100. This is often used where there is a

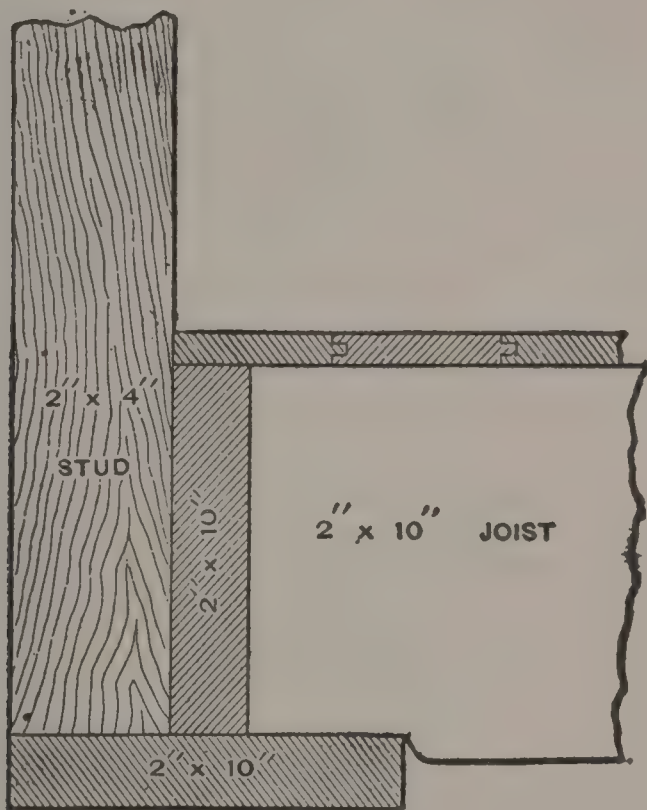


Fig. 99.

good foundation under it, it makes a very good sill, when the studding is cut so as to go down to the bottom and occasionally when spiked in the joist as well as the sill it makes a very strong job.

Fig. 101 is another strong way which can be con-

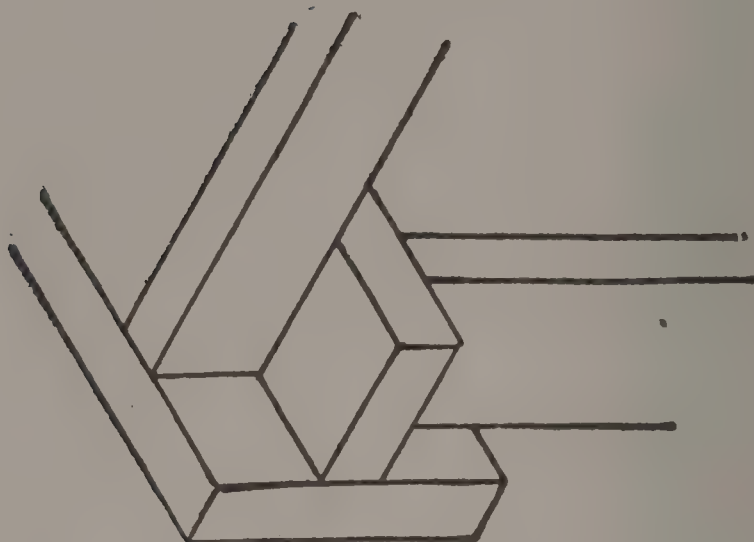


Fig. 100.

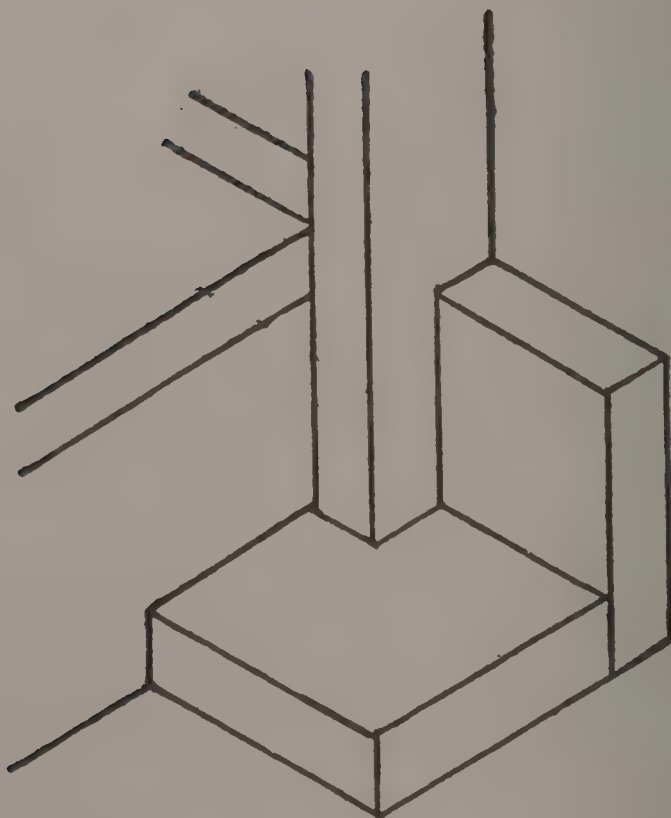


Fig. 101.

structed a little quicker and is good for a cheap job, but I prefer the other. Fig. 102 is cheaper still and used a good deal, just the one piece laid flat on the wall, the joist put on and a 2x4 nailed on the joist, and then the studding nailed to that. Or let the studding run down to the sill and do away with the 2x4 on the joist.

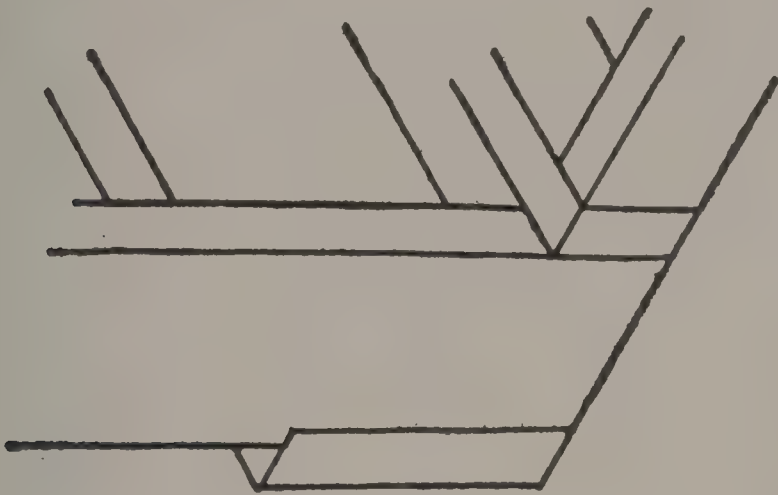


Fig. 102.

In forming partitions and walls in balloon and scantling buildings much care is required in arranging the studding at the corners and about the doors and windows in order to get the best results with as little expenditure of materials and labor as possible, and in order to aid the workman in this direction, I have gathered together from various sources a number of examples, the very best obtainable for this purpose and embody them in this department. Take for instance the corner posts in a balloon frame where it has to serve for receiving the finishing materials—board-

ing and lathing—on both its inner and outer angles. These should be straight, firm and solid, and constructed so as to make a good outside and inside corner. Fig. 103 shows a substantial way, simply by nailing four together strong with a good outside and nice inside corner to lath on. Fig. 104 is another way practically as good and saves one studding. But if the thickness of two was not the width of one it would bother a little.

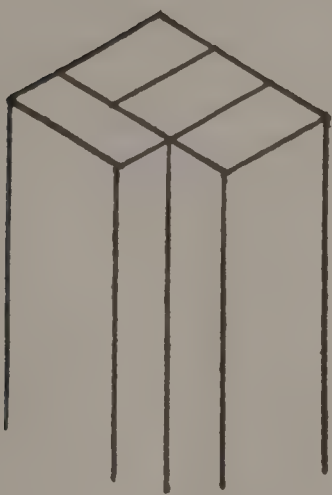


Fig. 103.

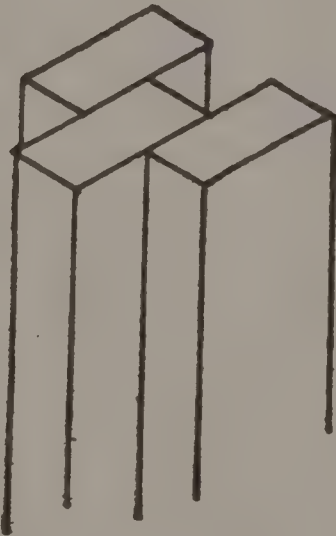


Fig. 104.

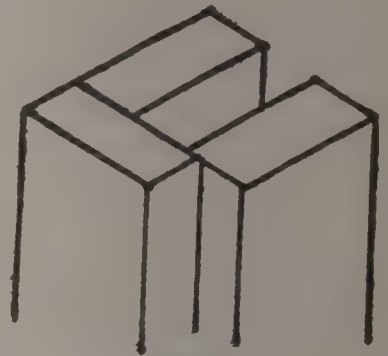


Fig. 105.

Fig. 105 is a method of nailing together the corner studding in a way to avoid the difficulty just mentioned and makes a good corner.

Fig. 106 shows how a good corner for a cheap job can be made with two studding; if the building is not sheathed a five-inch corner board nailed together at the corner works alright, and chamfered on the corner looks well, too. Of course, if

there was to be a quarter round in the corner that corner shown would not do at all. I think you all have a corner on that subject and now we will mention partitions. Fig. 107 shows that where the cross partition comes, the studding should be 3 inches (not 4) apart, and then spike the cross partition studding to them and you have a solid corner that the plastering will have no excuse to crack in. Fig. 108 shows corner of partition where the par-

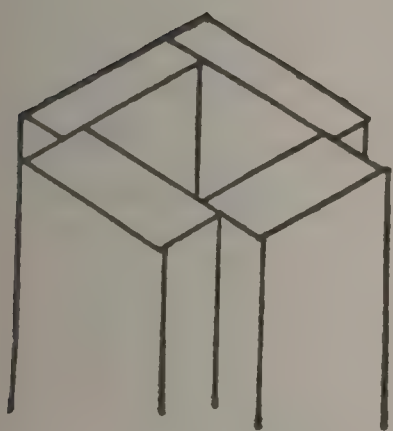


Fig. 106.

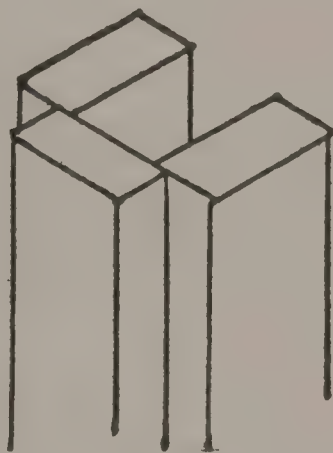


Fig. 107.

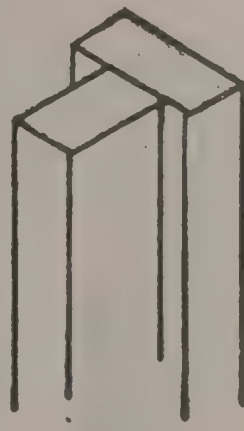


Fig. 108.

tition is put up the 2-inch way, as they often are in closets and light work. If you wish the building to show as high as possible on the outside and not have the ceiling too high on the inside, Fig. 109 shows a good method for plate and ceiling joists; for better job the plates could be doubled. Fig. 110 shows a double plate ceiling joist on top corner, cut to keep from projecting above rafter, which makes the best job for general purposes.

At Fig. 111 I show two other corners sometimes used. One of these shows the least amount of material that can be used for an outer corner while the other one shows a solid corner formed

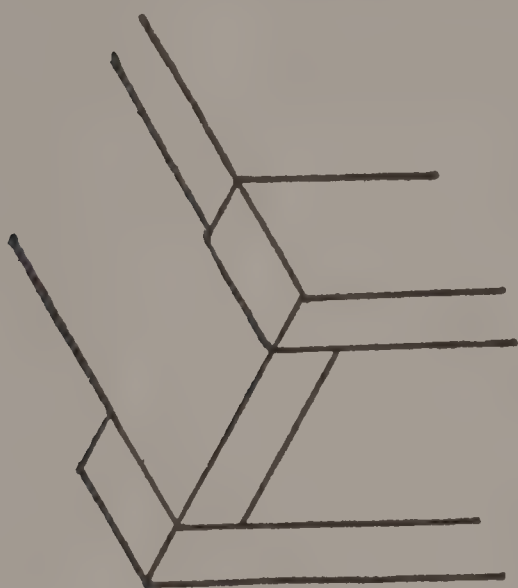


Fig. 109.

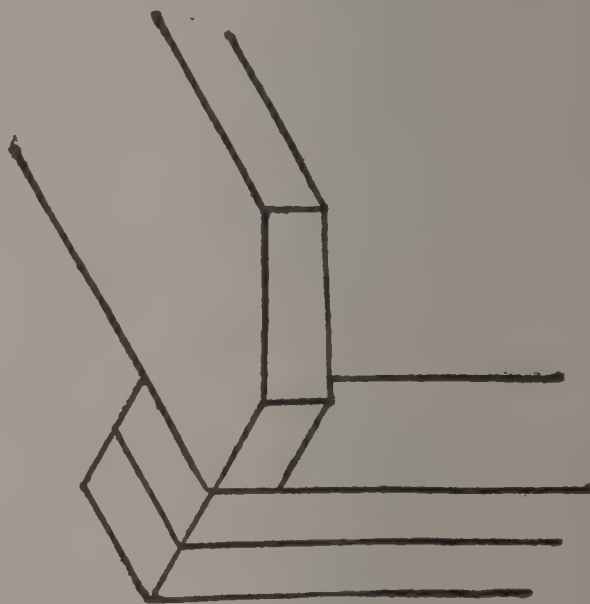


Fig. 110.

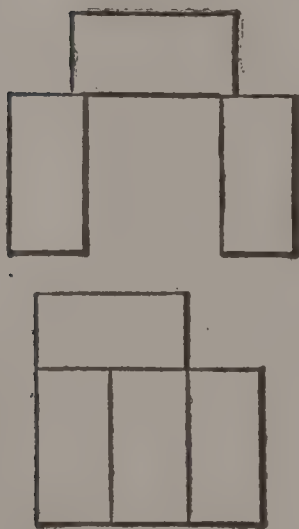


Fig. 111.

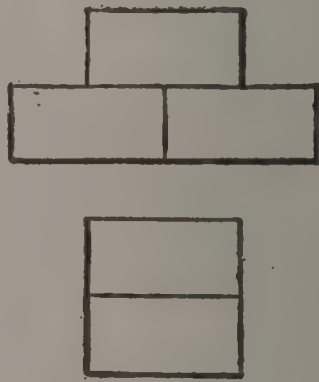


Fig. 112.

with four pieces and is similar to Fig. 103, and the other to Fig. 107. At Fig. 112 is shown two examples, the upper one is for the starting point of a partition, the lower one shows the double stud

to be used for the jamb studs for windows and doors. Fig. 113 shows the proper method of running lath behind a partition wall, X showing the stud starting the partition. This is not a good

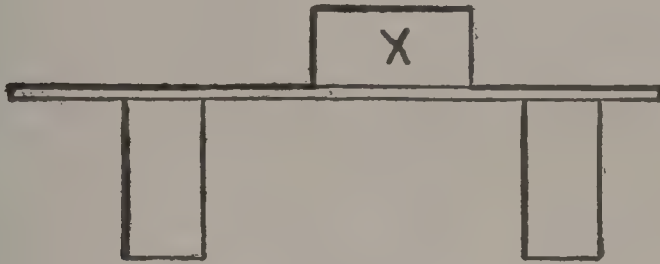


Fig. 113.

method, though very often made use of, as the angles are likely to crack. A much better way is shown at Fig. 114, which, if adopted, and done well will prevent the plaster from cracking. The 2x3-inch piece indicated by A in Fig. 114 should be

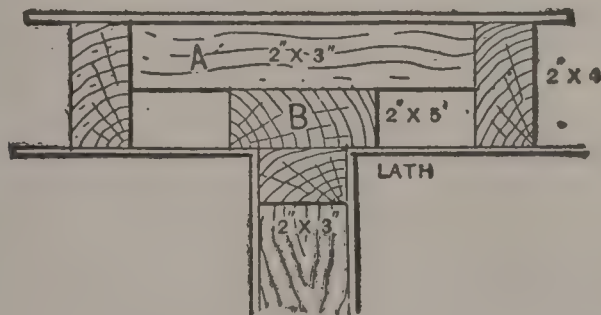


Fig. 114.

cut in every 2 feet in height of partition and well nailed, especially to the 2x5-inch B. When 2x3-inch studding is used in the main partition we would suggest employing 1x5-inch piece B, instead

of a 2x5-inch. Fig. 115 shows a section of a wall intended for a house having two stories, a cellar and attic. This shows the sill, cellar wall and

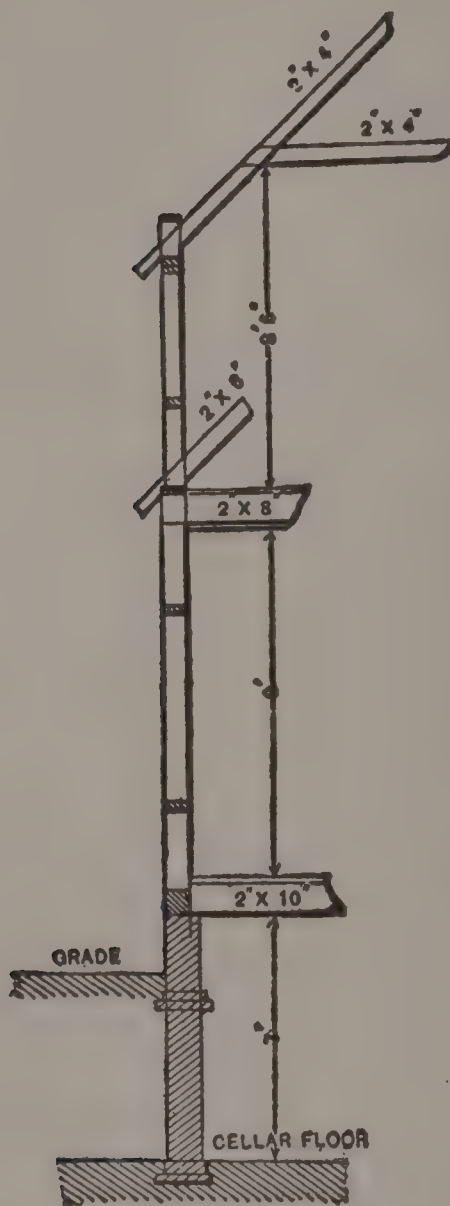


Fig. 115.

rafters of additional annex, the annex being only one story and cellar. Another sectional view of outside wall with inside and outside finish is shown at Fig. 116. This shows the manner of forming

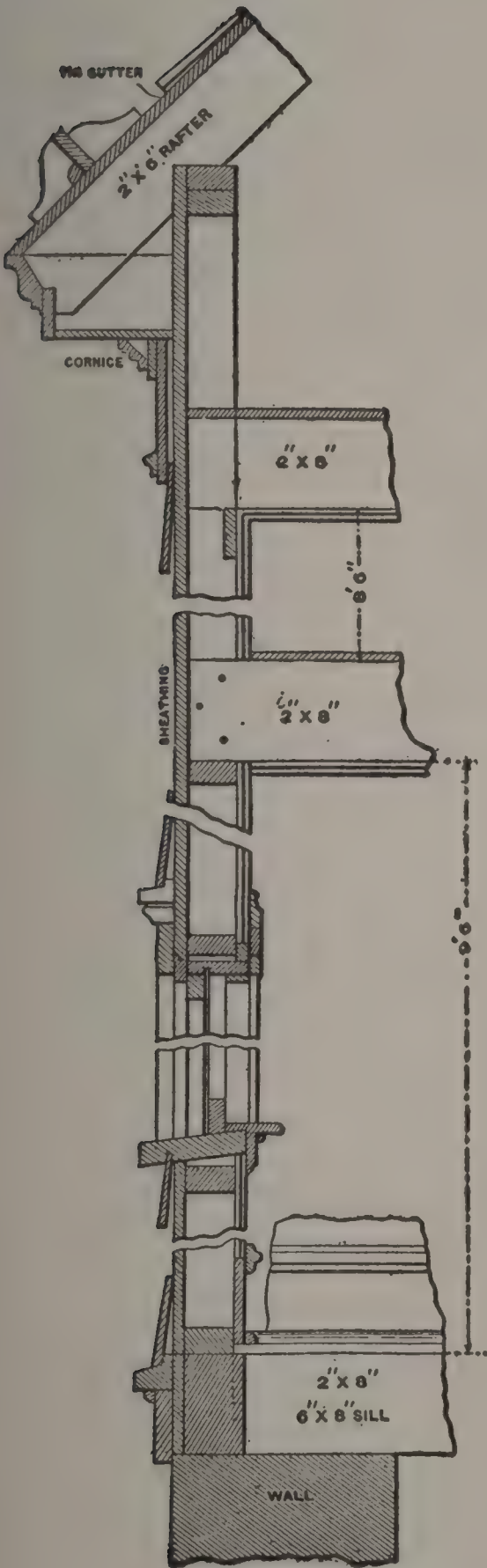


Fig. 116.

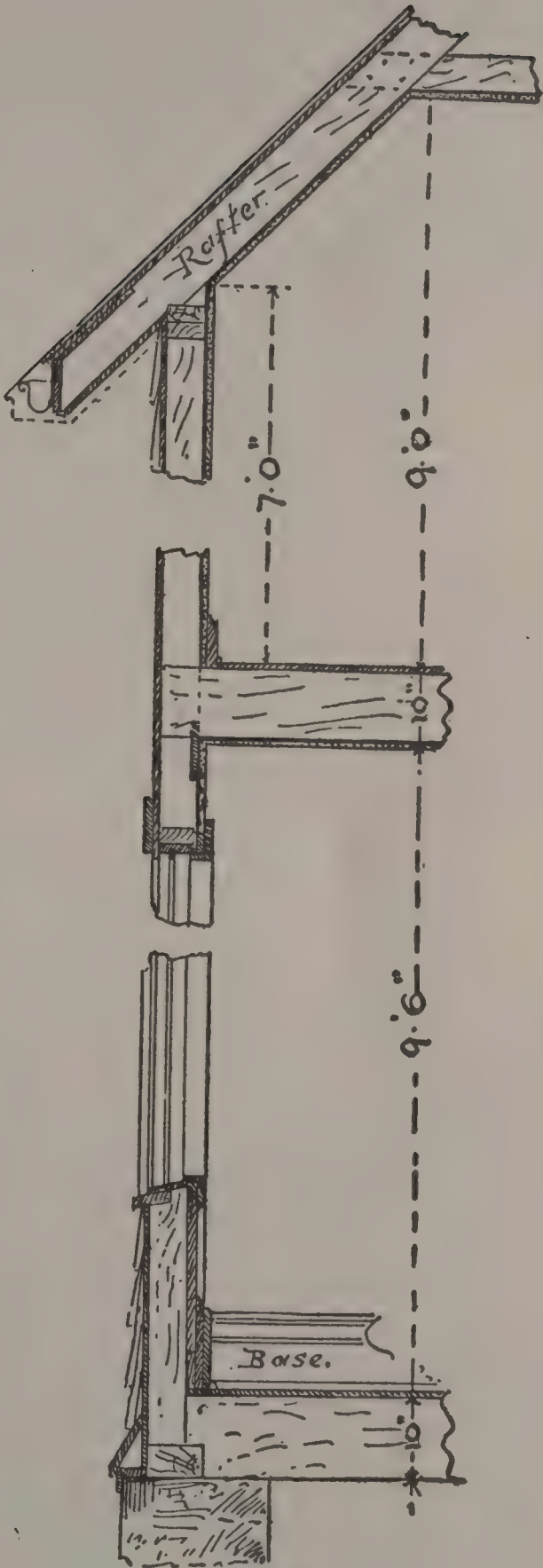


Fig. 117.

the sill, placing in window headers, cornice and general finish. As this section is drawn to a scale of half-inch to the foot, it may be worked from if desired. Another section of an outside wall

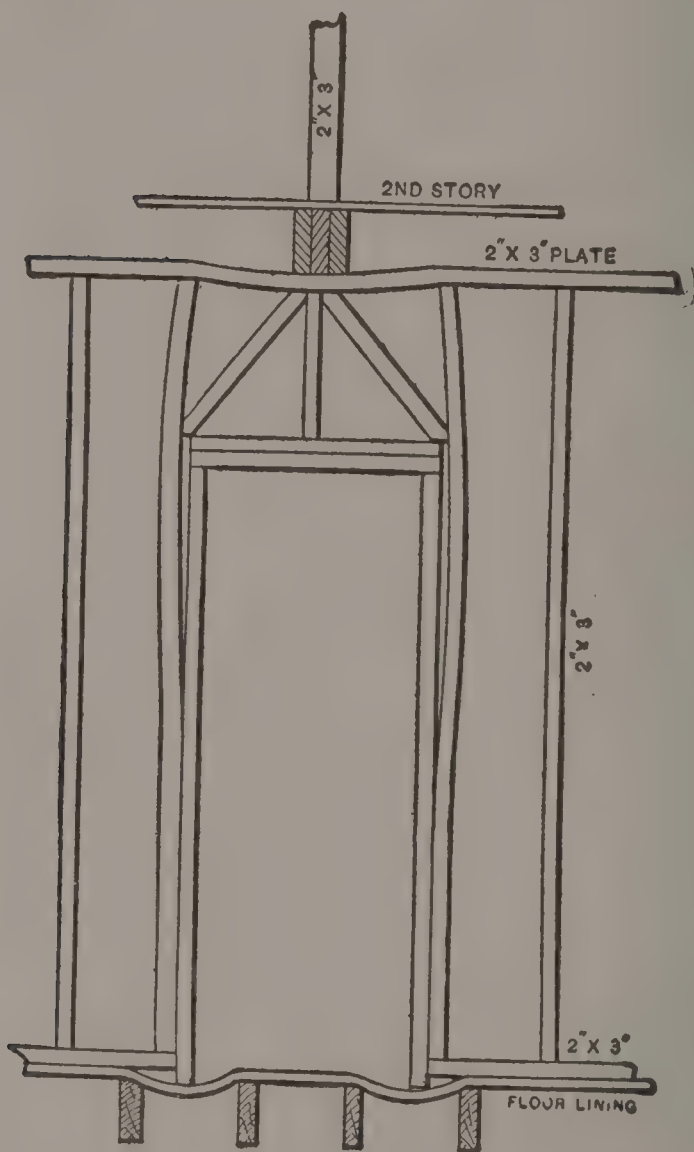


Fig. 118.

of a simpler kind is shown at Fig. 117. This is for a one and a half story house, finished quite plainly inside and out.

In setting up inside partitions more care and

attention than is usually paid to the openings should be given. A careless haphazard way of trimming the heads of doorways and the consequent result after a few years, is shown at Fig.

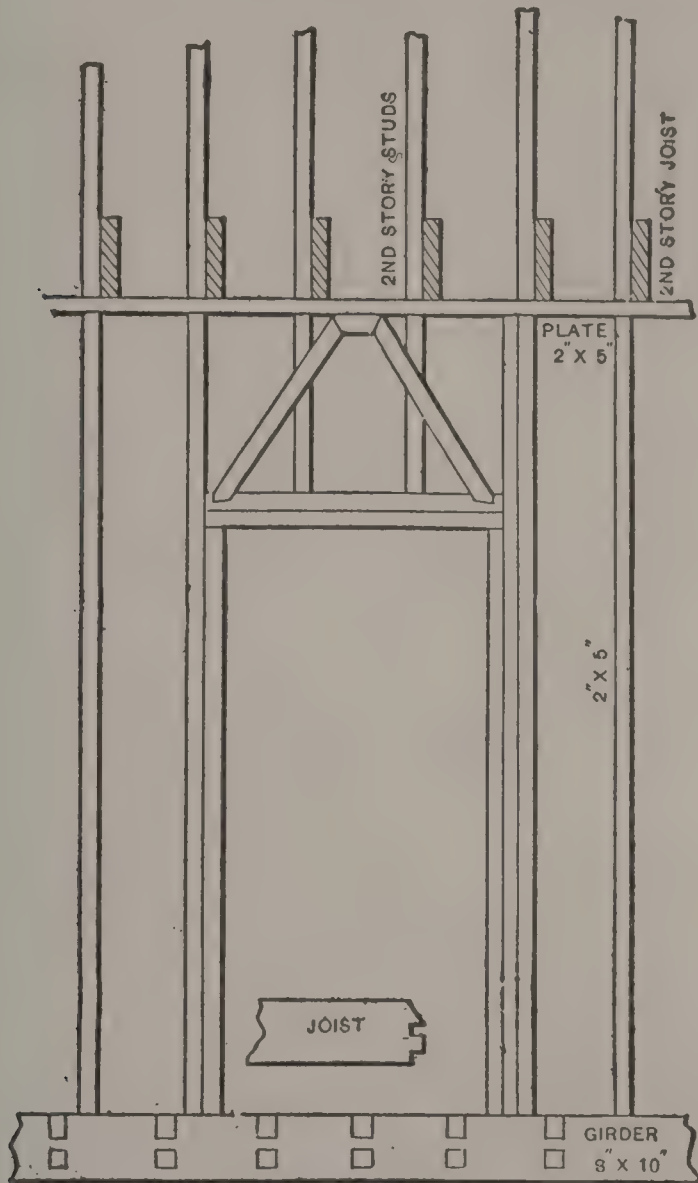


Fig. 119.

118. This figure, of course, shows the condition in an exaggerated form, but the condition does often occur very much to the detriment of the door and its trimmings. Fig. 119 shows a good old-

fashioned way of framing a door head so that no movement or distortion like that shown in 118 can possibly take place as the braces at the head

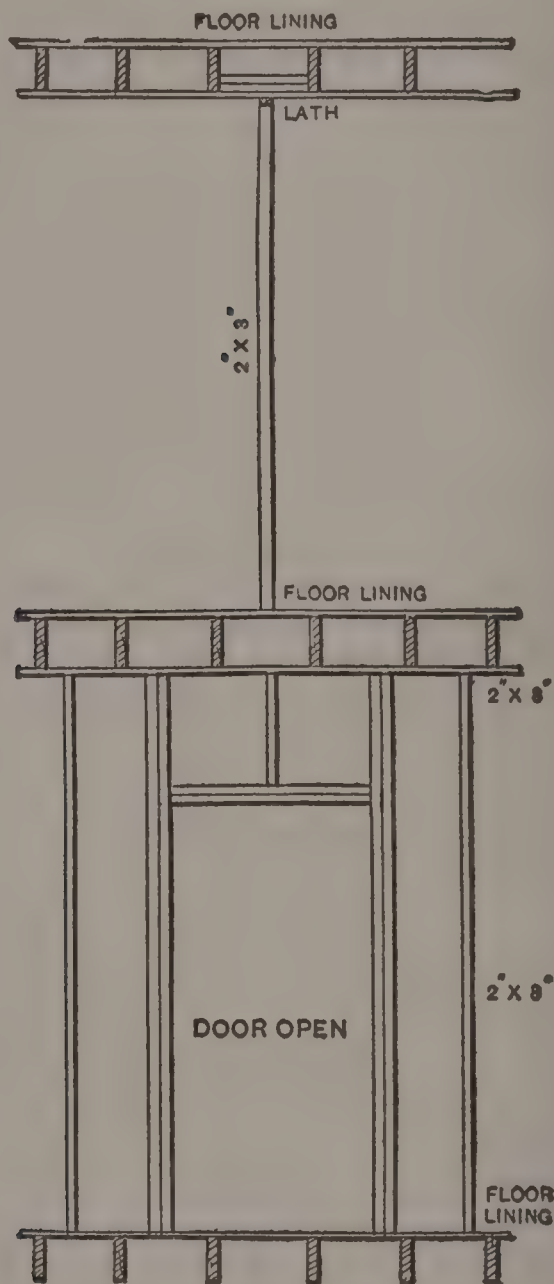


Fig. 120.

are toed, or notched, into the top stretcher which prevents them from pressing out the jamb studs. Another method which is quite common, and which

should be avoided, is shown in Fig. 120. This last is a cheap slip-shod way of fixing partitions over doors but it very often leads to trouble after the building is occupied, and it should be avoided in the interests of good and permanent work. The difference in cost between building a doorway as at Fig. 120 and Fig. 119 is so small that no

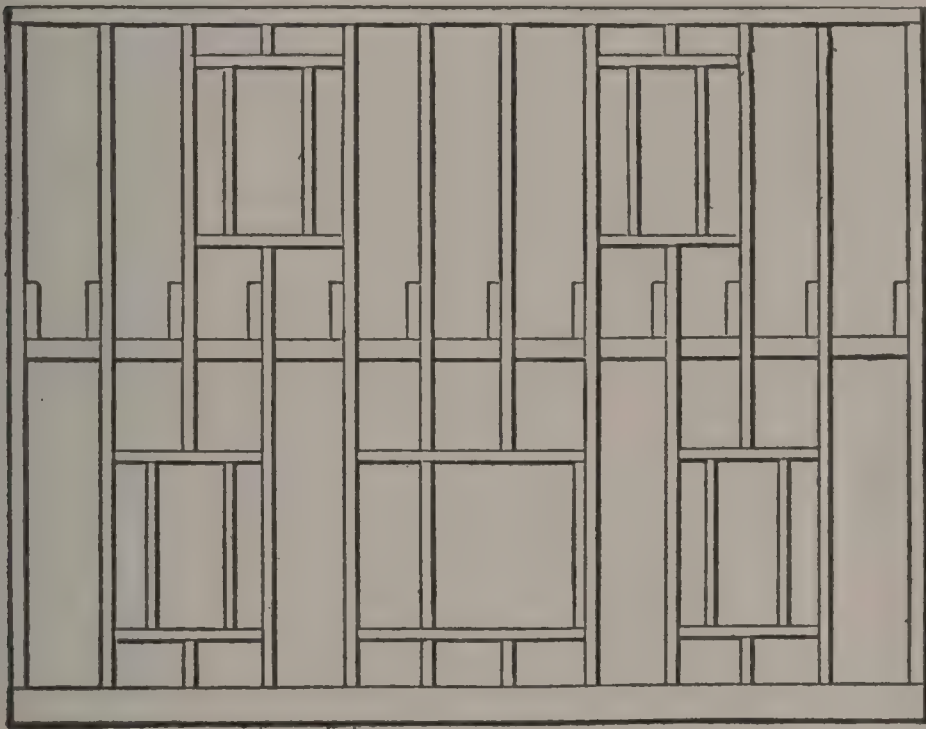


Fig. 121.

contractor should for a moment hesitate in adopting the better plan. The sill, or girder and joist shown in Fig. 119 need not be followed, they are exhibited just to show the old methods of doing good substantial work and may yet be employed in some situations. At Fig. 124, I show a portion of a floor with the end of the joist resting on a

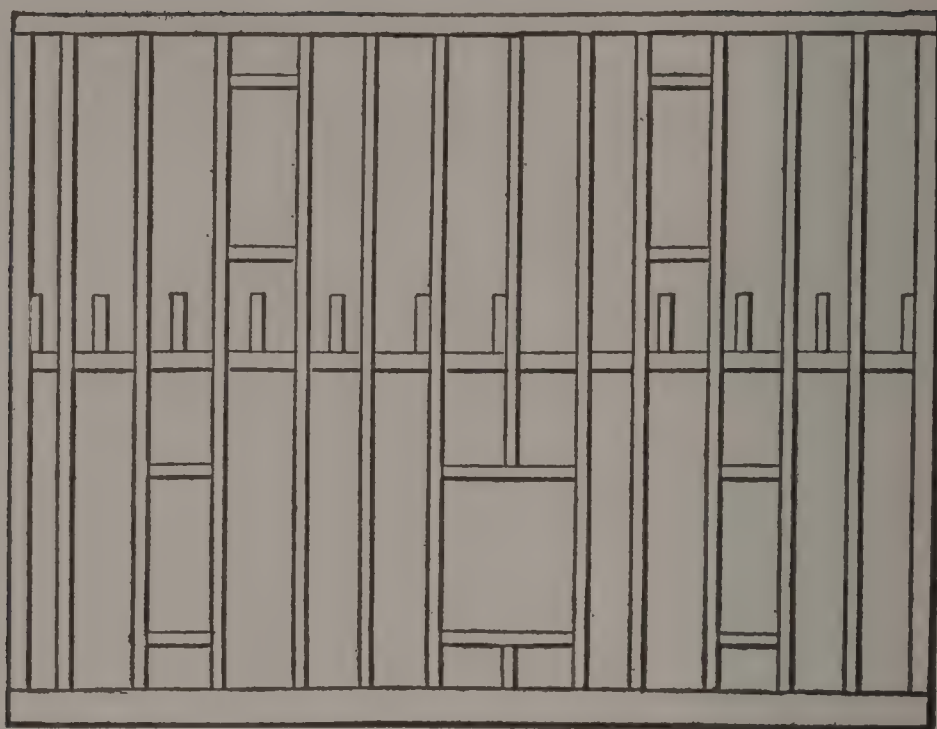


Fig. 122.

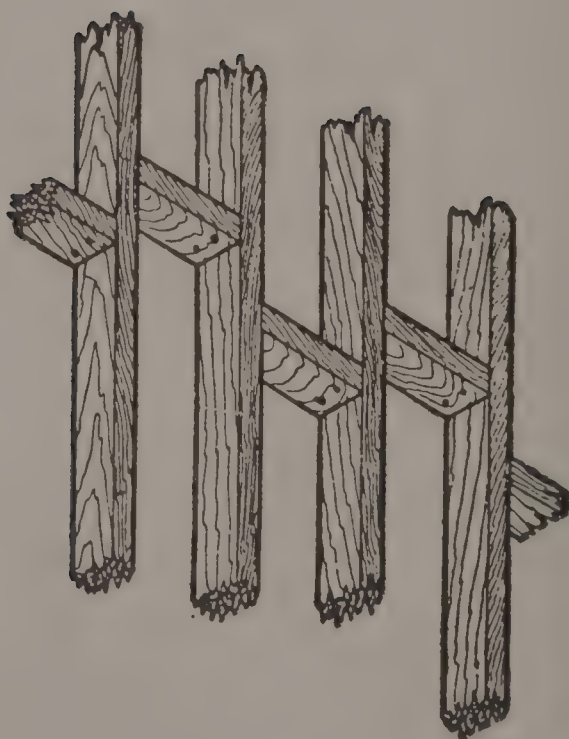


Fig. 123.

bond timber which is supported on a ledge formed in the brick wall by making the upper story one half a brick thinner than the wall below. This is

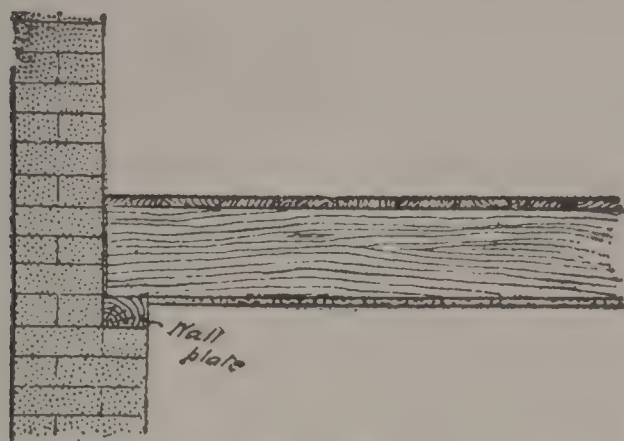


Fig. 124.

a very good way to carry the joists when it can be accomplished without injury to the wall and where the building is not more than three stories in height. Fig. 125 shows a section of a floor with

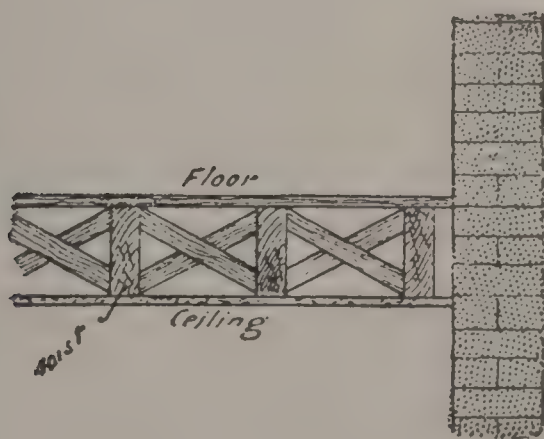


Fig. 125.

joists, floor, ceiling and cross bridging. This is a good example of building a good solid floor for all ordinary purposes.

Fig. 126 shows cross bridging with floor or ceiling and Fig. 127 exhibits the proper way to cut in the joists in a brick wall where it is necessary to run the joists in the brick wall. The joists should rest on a timber which is built in the wall as the bricks are laid.

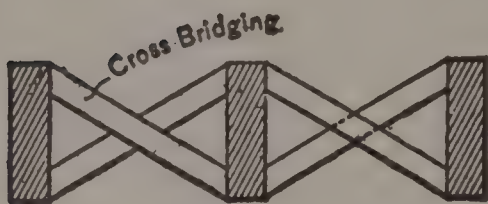


Fig. 126.

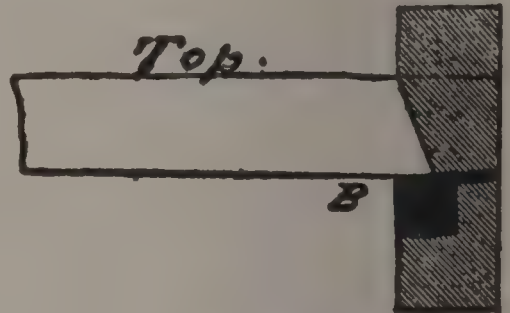


Fig. 127.

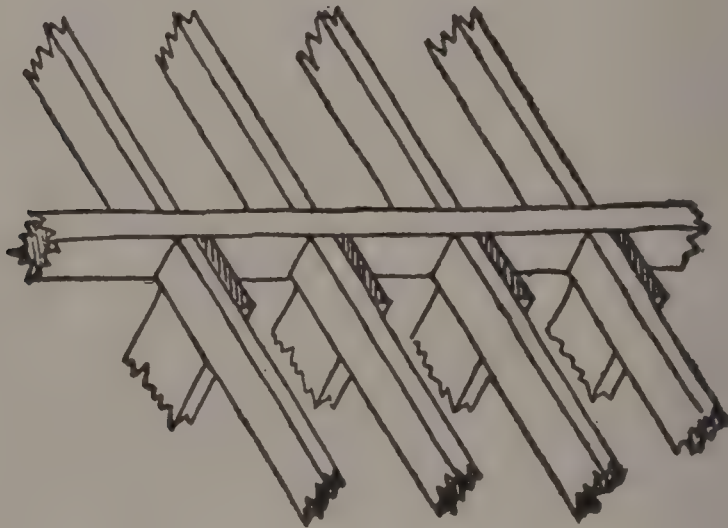


Fig. 128.

A good way to set up second or third-story studs is shown at Fig. 128. Of course, where the studing can be obtained long enough to run the whole height of the building it is better to get them if the cost will admit, if not, the method shown will

answer very well. Fig. 129 shows a good method of trussing a partition, it is simple and can be done without much labor and is quite effective.

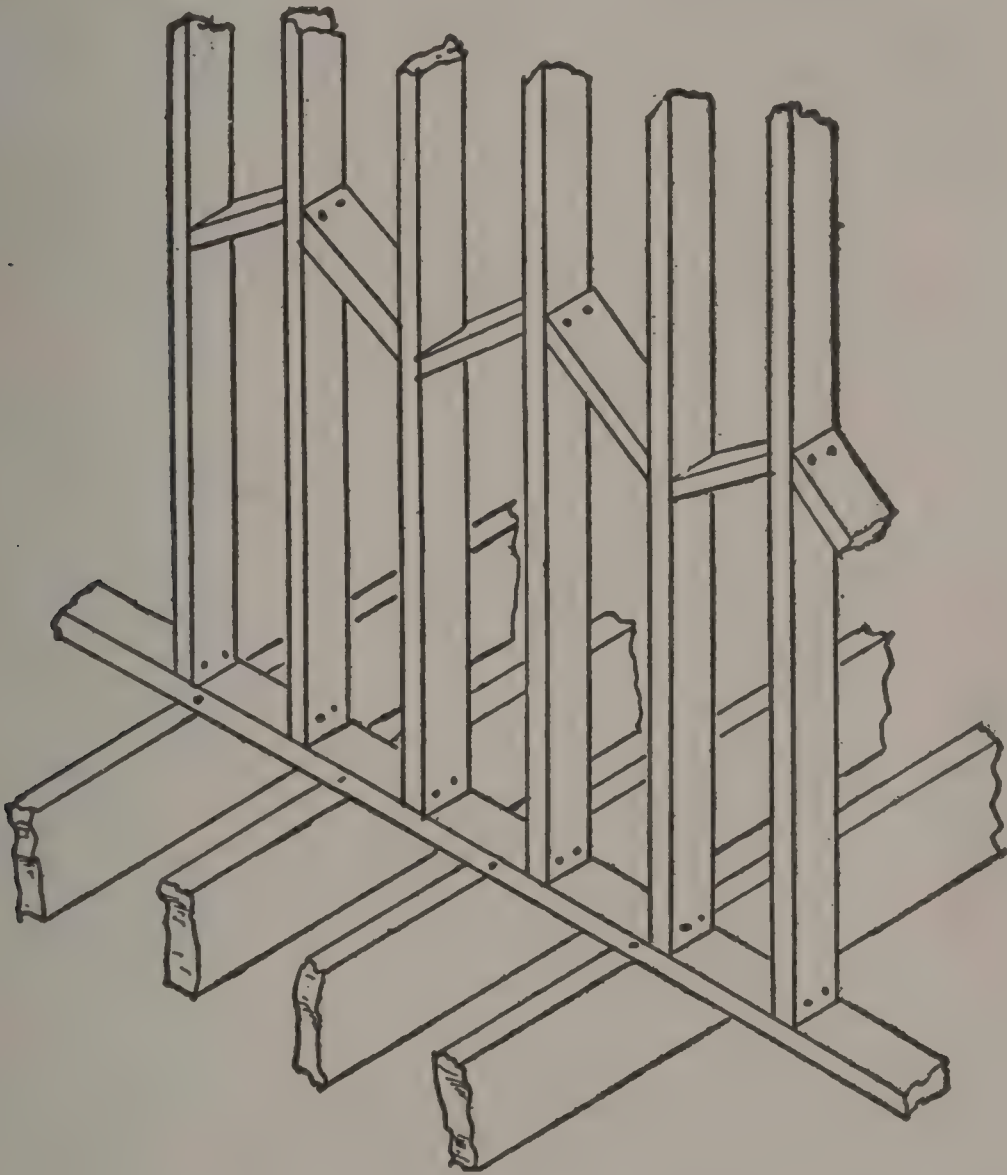


Fig. 129.

At Fig. 130 I show a method of preparing a wall of scantling for veneering with brick; it is simple and does not require much skill to make a good wall. The proper way is to put down a stone foundation wall of sufficient thickness to carry both

framing and brick wall, as shown at Fig. 130. The brickwork is tied every sixth course with proper anchors, as shown, which are about 6 inches long, and which are nailed to the sides of the studs. The studding may be 2x4 or 2x6 inches, and framed in the ordinary manner. It is considered the better way to rough board the outside of the studding and then cover the boarding with good building

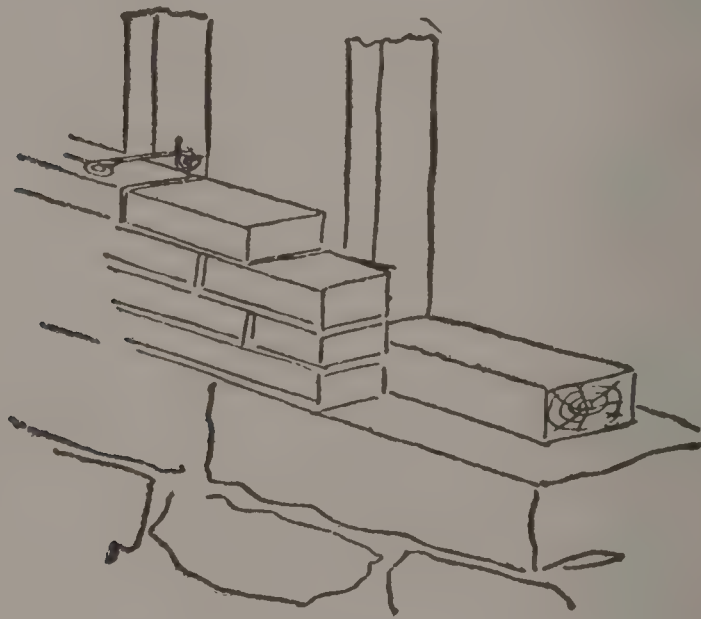


Fig. 130.

paper, and brick against this. A good warm job is the result if the work is properly done. The bricks are all well laid as “stretchers” when done this way, and the best bricks should be selected for the work. At this point it may not be out of place to show some of the methods of laying down joists and securing hearth and stair trimmers, and other similar work. As I have shown in Fig. 127, all

joists entering in a wall should be cut with bevel ends, so that in case of fire and the joists being burned or broken in or about their centers, then should they fall down, they would pry out either the bricks or stone above them and thus tend to destroy the wall. The employment of bridging as shown in Figs. 125 and 126 is for the purpose of stiffening the joists by keeping them from twisting, and distributing the strain over a larger number of joists than those on which the weight comes. The bridge piers should be 2x2 inches, though 1x2 are frequently used, and they should be accurately cut to the required angle and firmly nailed. A good way to find the lengths and bevels of the pieces required for the braces is to snap a chalked line across the top edges of the joists, parallel with the side of the wall, and a second line distant from the first, just the depth of joists, and of course, parallel to the first line. The length and angle of the braces can then be obtained by laying the piece diagonally on the joists, with its edges just touching the chalk lines on the inner edge of both joists, keeping the thickness of the stuff inside the two lines. In this position mark the underside of the bridge piece with a pencil, and both the proper angles and right length are given. Each piece obtained this way answers for the second piece in the same space. Two nails should be driven in each end of the bridge piece, if a good permanent job is desired.

In trimming around a chimney or a stair well-hole, several methods are employed. Sometimes the header and trimmers are made from material twice as thick and the same depths as the ordinary

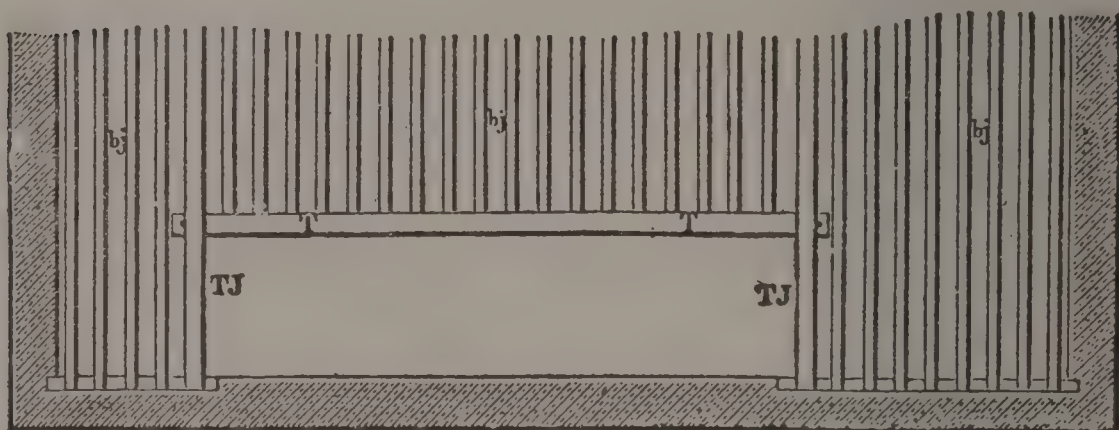


Fig. 131.

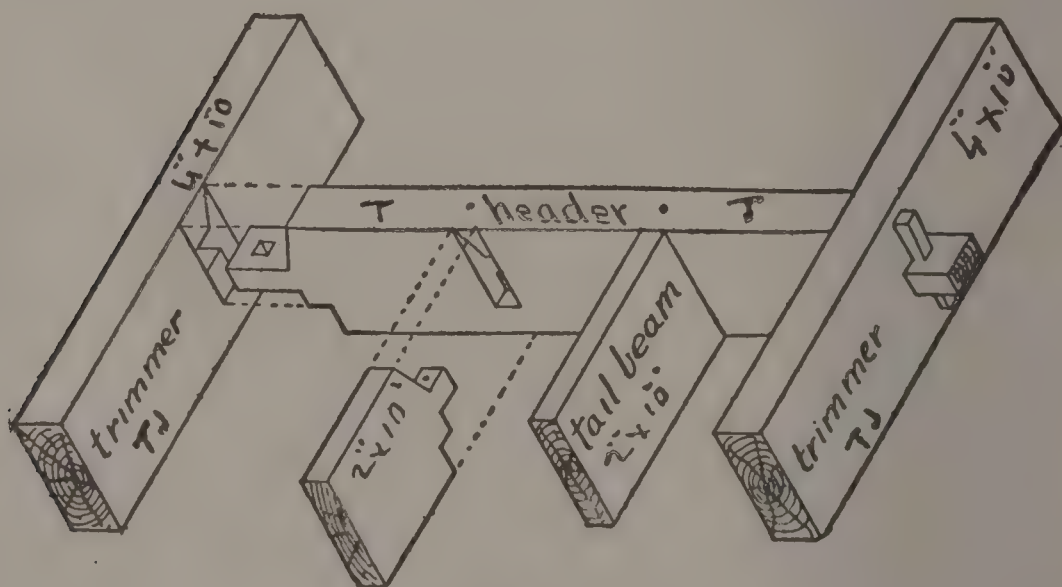


Fig. 132.

joists, and the intermediate joists are tenoned into the header, as shown in Figs. 131 and 132. Here we have T, T, for header, and T, J, T, J, for trimmers, and *b*, *j*, for the ordinary joists. In the western and also some of the central states, the

trimmers and headers are made up of two thicknesses of the header being mortised to secure the ends of the joists. The two thicknesses are well nailed together; this method is exhibited at Fig. 133, which also shows one way to trim around the hearth; C, C, C, C, shows the header with tusk tenons on ends, which pass through the trimmers A, A.

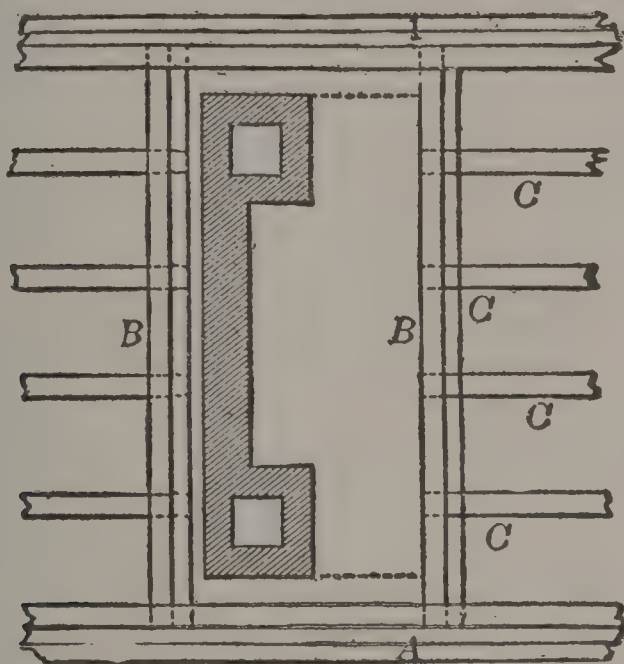


Fig. 133.

At Fig. 134 I show another scheme for trimming around a fireplace in which the trimmers and headers T, T, are seen, the headers being tenoned through the trimmer joists with tusk tenons and keyed solid in place. The central line of hearth is seen at X Y, the intermediate joists at *b j* and the trimmers at *t j*, while the bond timbers are in evi-

dence at *w p*. Here there are two flues shown, also the hearth tiling. In this example there are two holding bolts shown by dotted lines on each side of the fireplace anchored into the brick-wall and passing under the hearth and through the header to which it is secured with a nut and washer. A dump grate is shown at *s s*. This is for the purpose of letting ashes down a chute into the cellar where there should be an iron receptacle to receive them.

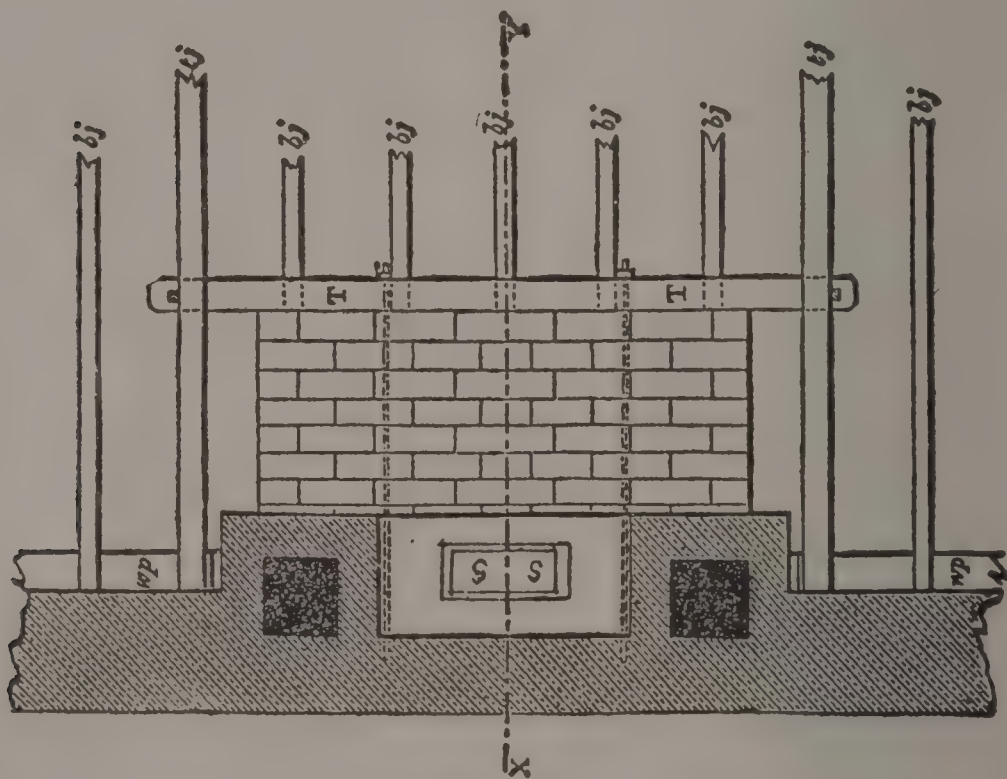


Fig. 134.

Fig. 135 shows a sectional view of the hearth *X Y*, of Fig. 134. This shows a brick arch turned under the hearth to support it, the center for which the carpenter is expected to make. There is an

oak or other suitable hardwood strip mitred around the tiles and of the same thickness as the flooring. The flooring is shown at *b*, and the joists and trimmer are shown at *b j* and *t j*, respectively; the dump shute is shown at the shaded part and may continue to cellar floor, or cut through the wall at any desirable point convenient to remove ashes.

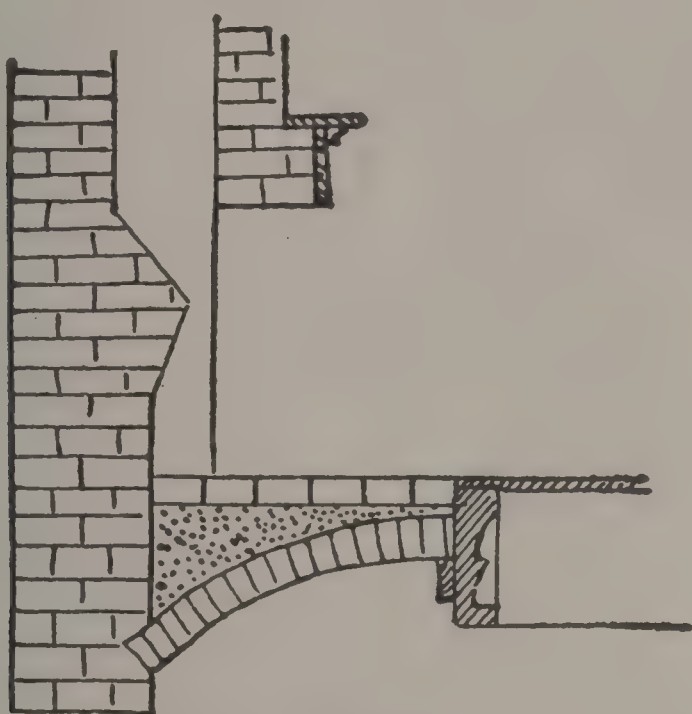


Fig. 135.

In ordinary buildings the brick arch is seldom employed, the header being placed pretty close to the brick work and the joists tenoned into it, and the tops of the joists being cut down enough to allow a layer of concrete cement and tiles on the top of them without raising the tiles above the floor. In such cases strips are nailed to the sides

of the joists, three or four inches below the top of the cut joists. Rough boards are then laid in these strips after which the space is filled in with coarse mortar to the level of top edges of joists, then the concrete cement and tiles are laid on this, which makes the hearth pretty safe from taking fire and brings the tiles to the floor level; where it may not be considered safe to trim down the joists to this requirement, the joists may be beveled on their top edges saw-tooth shape, and this will serve the purpose nearly as well as cutting them down below their top edges three or four inches.

Frequently it happens that a chimney rises in a building from its own foundation, disconnected from the walls, in which case the chimney shaft will require to be trimmed all around as shown in Fig. 133. In cases of this kind the trimmers A, A, should be made of stuff very much thicker than the joists, as they have to bear a double burden, B, B, shows the heading, and C, C, C, C, the tail joists. B, B, should have a thickness double that of C, C, etc., and A, A, should at least be three times as stout as C, C, this will to some extent equalize the strength of the whole floor, which is a matter to be considered in laying down floor timbers, for a floor is no stronger than its weakest part.

There are a number of devices for trimming around stairs, fireplaces and chimney stacks by which the cutting or mortising of the timbers is avoided. One method is to cut the timbers the

exact length, square in the ends, and then insert iron dowels—two or more—in the ends of the joists, and boring holes in the trimmers and headers to suit and driving the whole solid together. The dowels are made from $\frac{3}{4}$ to 1" round iron. Another and better device is the "bridle iron," which may be hooked over the trimmer or header, as the case may be, the stirrup carrying the abutting timber, as shown in Fig. 136. These

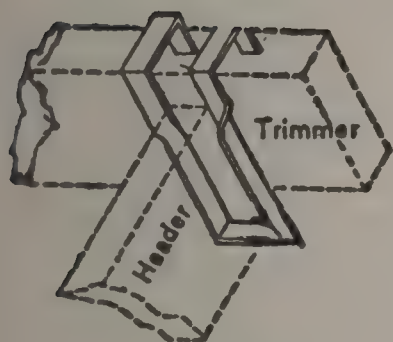


Fig. 136.

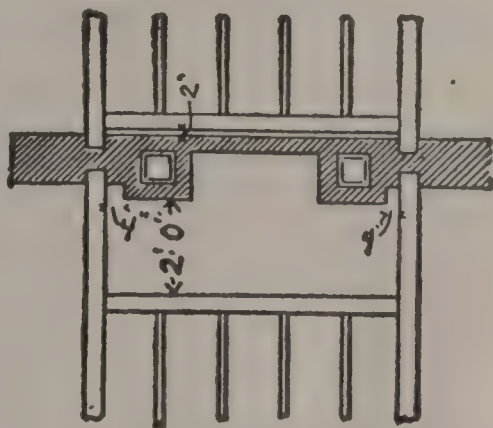


Fig. 137.

"bridle irons" are made of wrought iron, $2 \times 2\frac{1}{2}$ inches or larger dimensions if the work requires such; for ordinary jobs, however, the size given will be found plenty heavy for carrying the tail joists, and a little heavier may be employed to carry the header. This style of connecting the trimmings does not hold the frame work together, and in places where there is any tendency to thrust the work apart, some provision must be made to prevent the work from spreading. This

may readily be done in many ways that will suggest themselves to the workman. Perhaps the best way is to nail a hoop iron across the points lapping one end up the side of the trimmer or header, and bending it over the arris, running it along the edge of the joists across the joints, and extending it beyond the joints ten or twelve inches.

In no case where a trimmer or header is placed alongside a chimney stack should the woodwork be less than $1\frac{1}{2}$ inches from the brickwork. This is a precaution taken to prevent the heat of the stack from setting fire to the timbers; the flooring of course is obliged to be within one inch of the brickwork, but the bare board always covers the joint.

I show a few examples of trimming around a fireplace or chimney. Fig. 137 shows a very good way, and one very frequently employed. Another way, and one deserving of consideration is shown in Fig. 138. The ends of the stretchers enter the brick wall of the chimney, into which has been inserted cast-iron shoes to receive them. These shoes prevent sparks or fire from reaching the timbers from the flue and make them secure against burning. At Fig. 139 I show a trimmer with double mortises, also notches in the ends of the stretchers. These notches are to fit over a raised rib of iron in the cast-iron shoes, I show in Fig. 138. Notches are sometimes cut in the stretchers, to fit over a bar of iron which is sometimes used to carry joists over an opening where

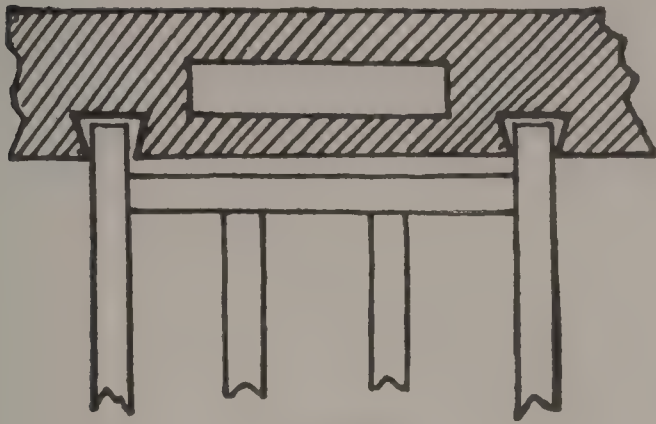


Fig. 138.

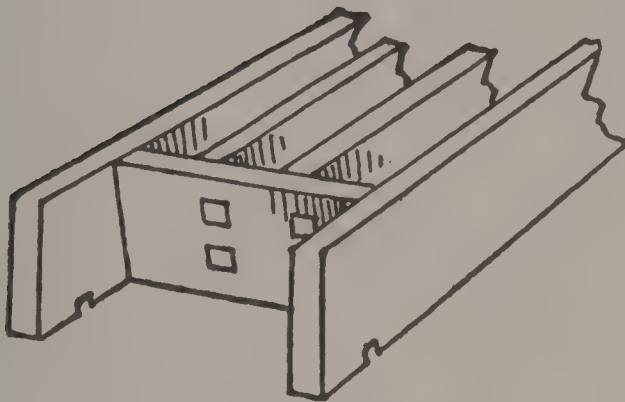


Fig. 139.

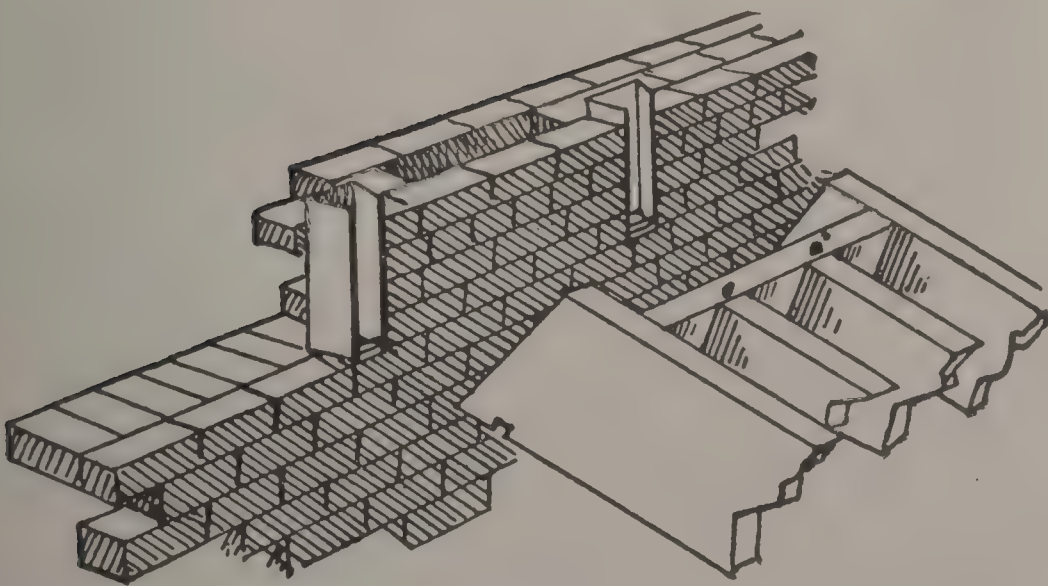


Fig. 140.

joists cannot be let into the brick wall, as shown at Fig. 140. This also shows how joists may be carried over small openings by making use of a flat iron bar which has screw bolts run through them to carry the joists below. Where a girder or timber is used to carry joists it is sometimes necessary to drop the timbers two inches, thereby affording greater strength in the beam, but with the disadvantage of projecting below the ceiling. Fig. 141 shows the proper proportions for framing

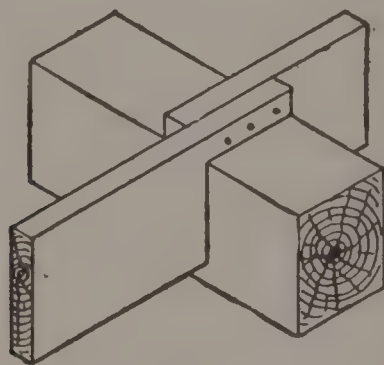


Fig. 141.

the end of the joists. In trimming for a chimney in a roof the “headers,” “stretchers” or “trimmers” and “tail rafters” may be simply nailed in place, as there is no great weight beyond snow and wind pressure to carry, therefore the same precautions for strength are not necessary. The sketch shown at Fig. 142 explains how the chimney opening in the roof may be trimmed—the parts being only spiked together. A shows a hip rafter against which the cripples or jacks, on both sides.

are spiked. The chimney stack is shown in the center of the roof—isolated—trimmed on the four sides. The sketch is self-explanatory in a measure and should be easily understood.

We may now venture to build a small house and finish same on the lines laid down, that is to say, a balloon frame house. We already know enough

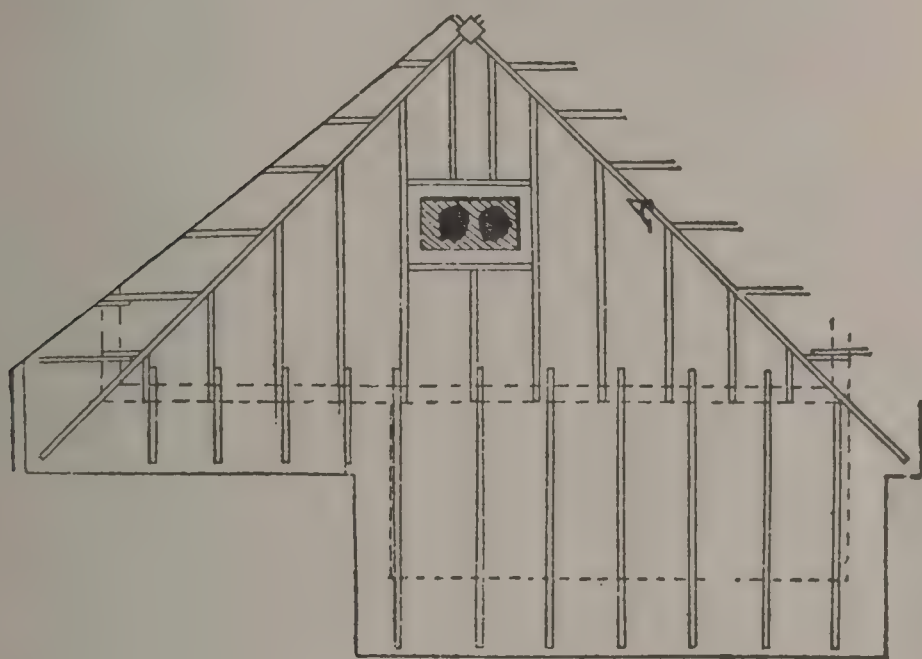


Fig. 142.

to raise the walls, put up and complete partitions and trim and finish openings. Suppose our building to be 24x42 feet on the ground. This should be laid off as shown in Fig. 143, first the foundation, then the first floor as shown, then the second floor with three bed-rooms, hall and closets. The manner of laying the joists is shown in Fig. 145. The joists are laid on the cellar or foundation

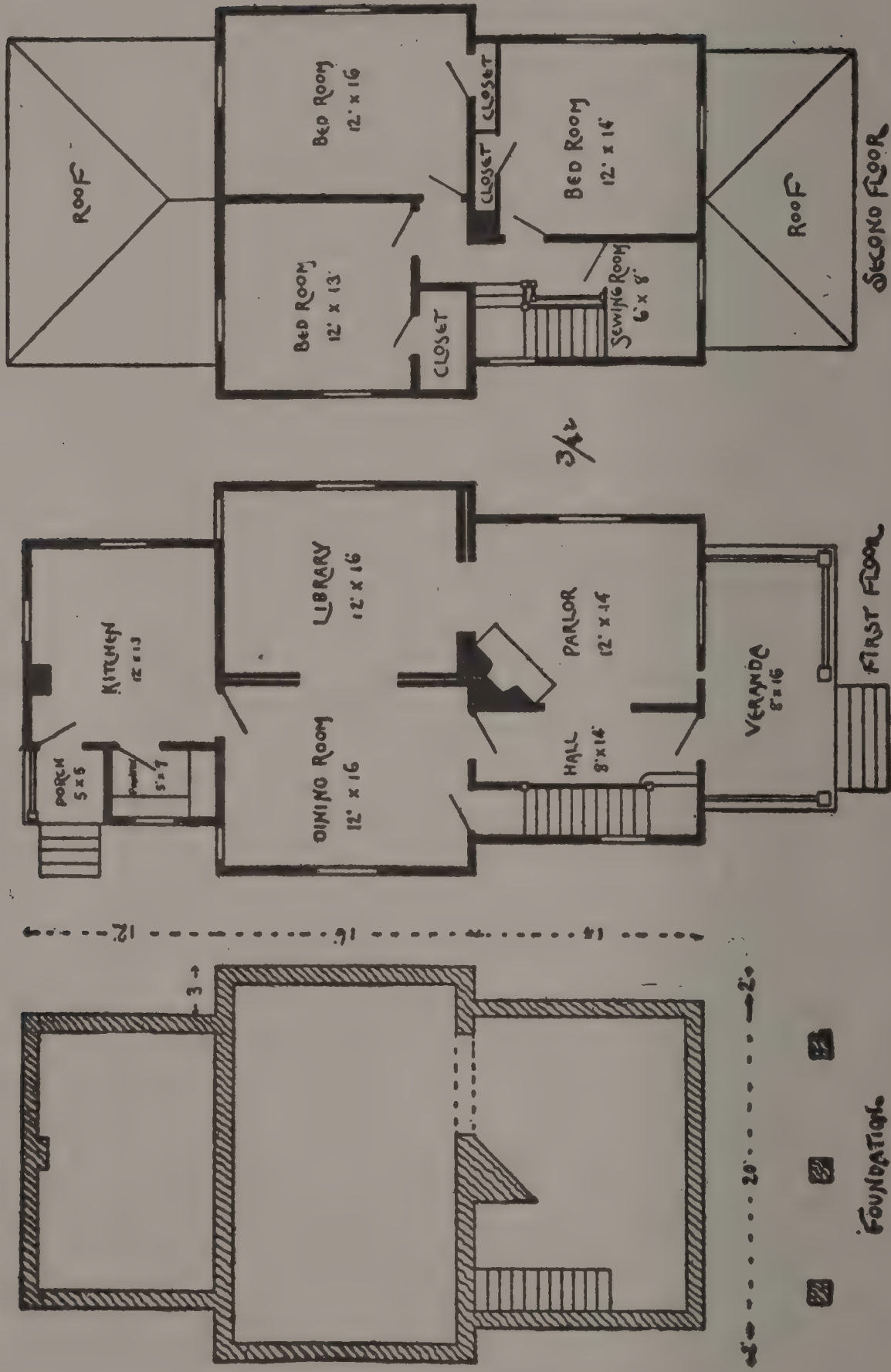


Fig. 143.

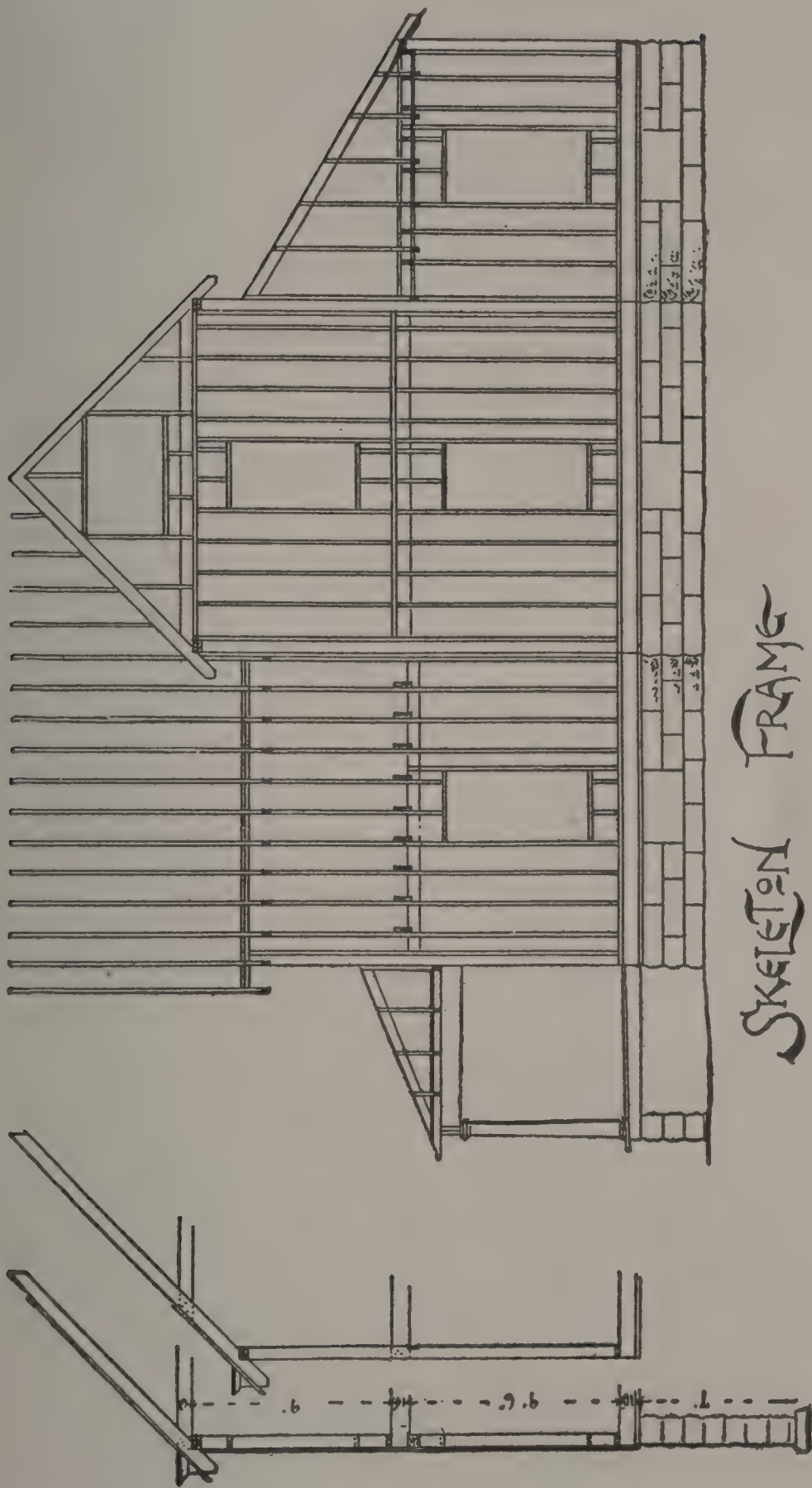


Fig. 144.

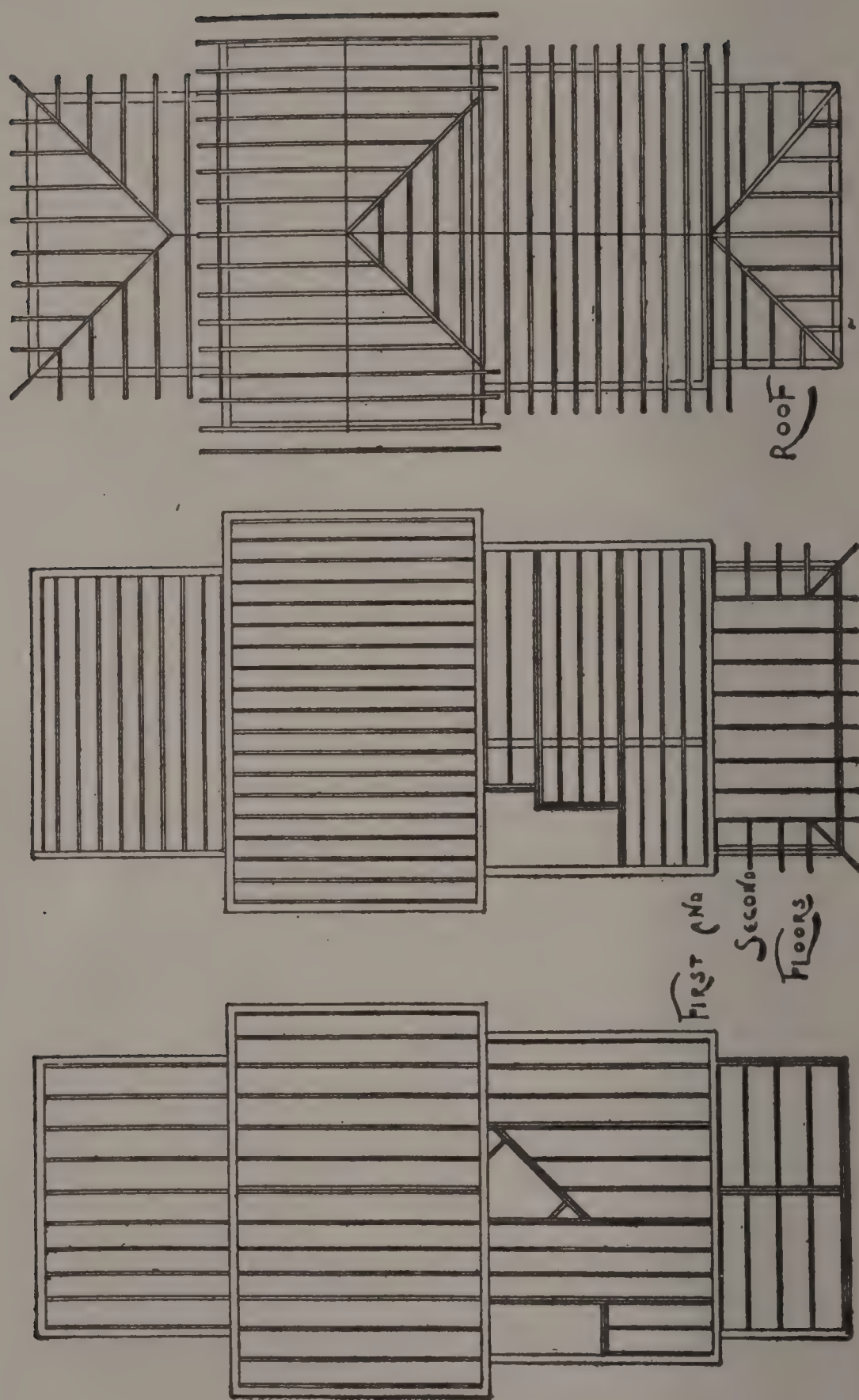


Fig. 145.

walls, for the first floor, then a rough floor may be laid on these joists, and the string pieces for the partitions may be laid on this floor, or the partition studs may rest on the joists, good solid provision being made for this purpose.

Before the partitions are built in, the outside walls must be put up and properly plumbed and braced. These walls must rest on sills formed on the lines of some one of schemes or sections shown in the preceding pages. A section of one side of the house showing the bare walls is produced at Fig. 144. This figure shows the openings for windows, also ends of porch and kitchen, with two sections of roof on different levels. The lines of joists on the second floor are shown in Fig. 145, also the direction of rafters, ridges and hips in the various roofs. While the house under discussion is a small one, the methods of erection are those that may be applied to the building of all kinds of balloon structures, large or small.

A building of greater pretensions is shown at Fig. 146. The windows and doors show double studding all round. This is always a good plan to adopt, but necessarily uses up quite a lot more material than is actually required; 2x4 blocks nailed on the studs here and there, would answer quite well to nail the finish to, but if a building be boarded on both sides of the wall, neither blocks nor a second stud would be necessary. One objectionable feature in this frame is the use of 2x8-

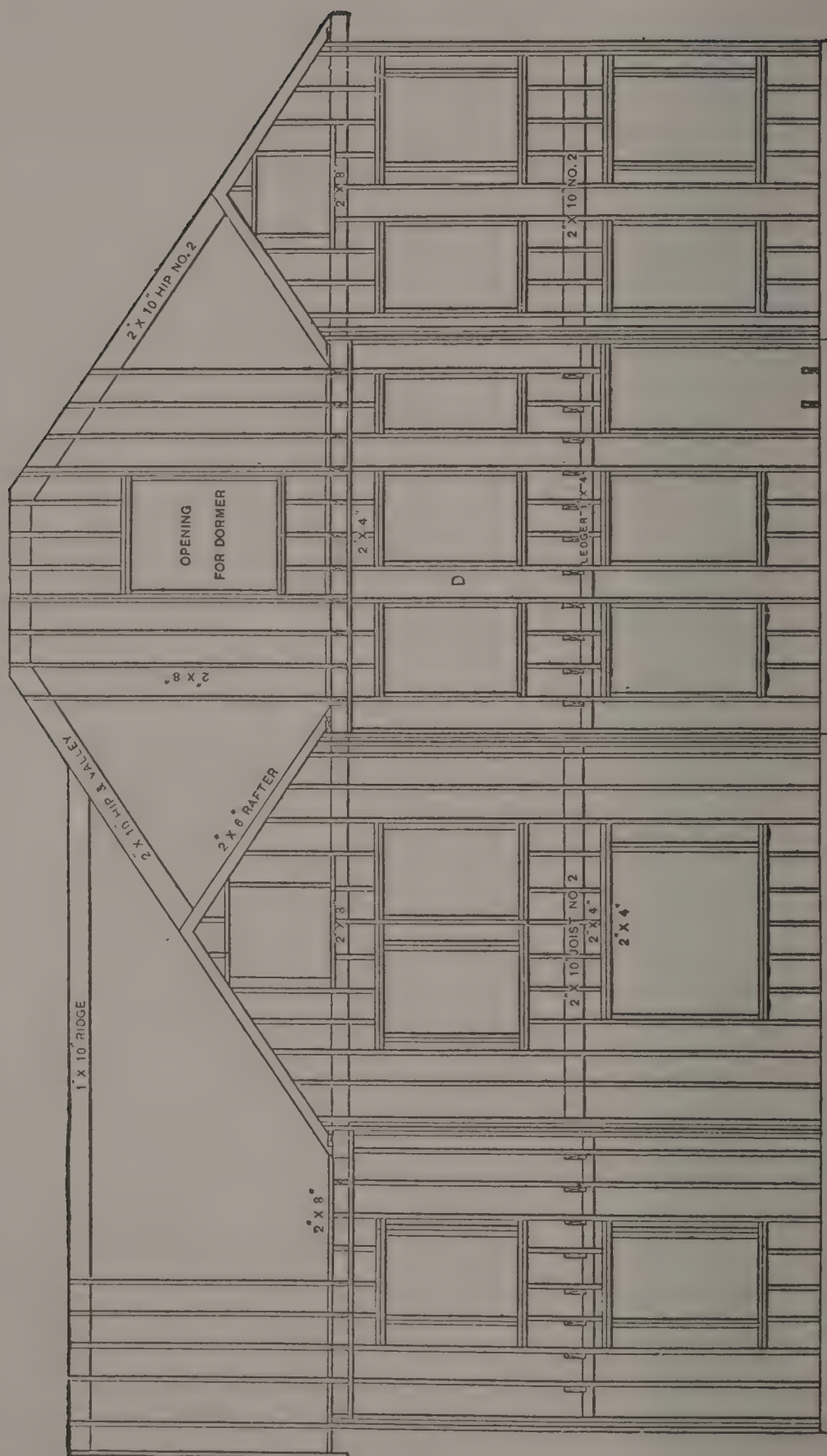


Fig. 146.

inch joists in the attic floor. These joists are too light for the space they run over; they should at least be 2x10-inch, then there would be little danger of the floor sagging, particularly if the floor joists were well bridged.

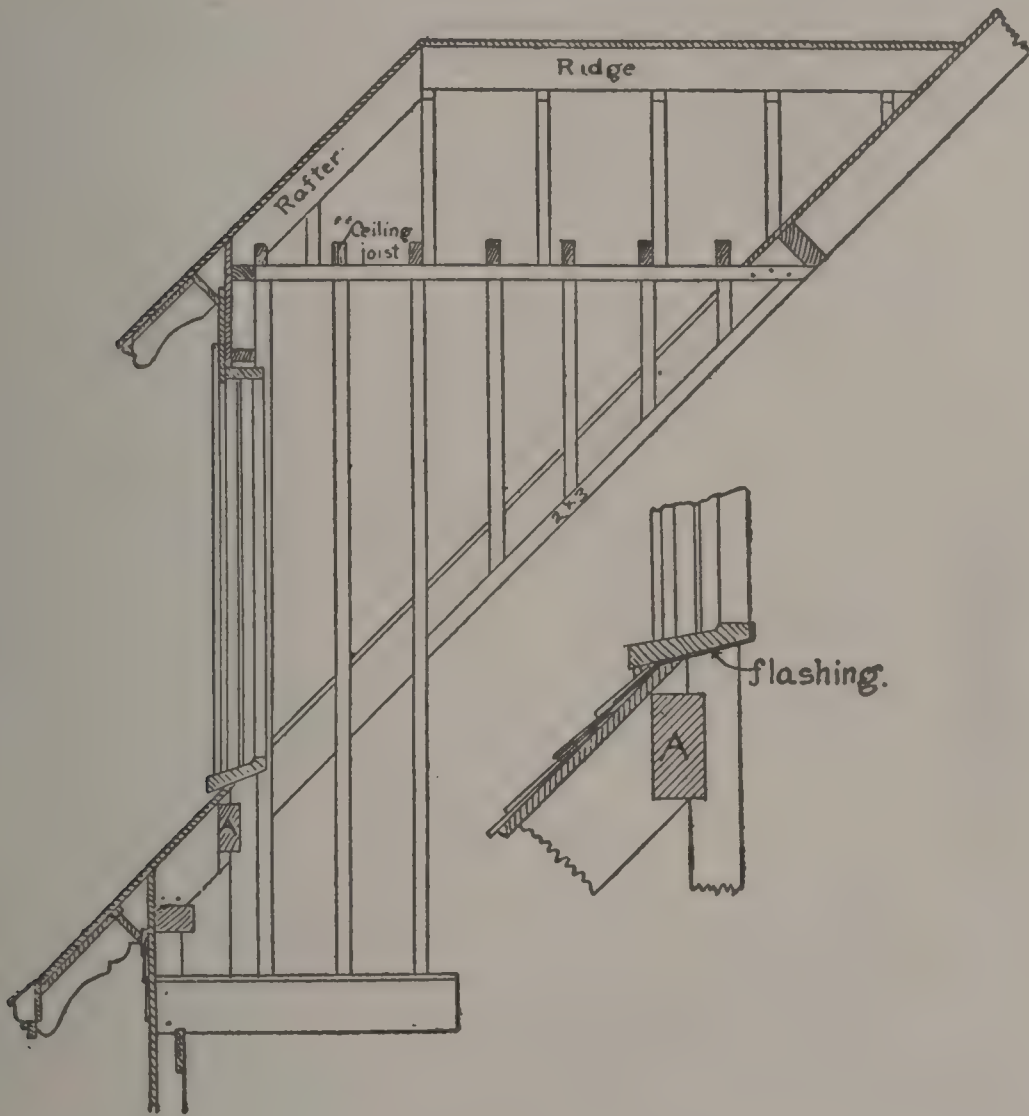


Fig. 147.

Dormers should be framed as shown in the section drawing, Fig. 147. An opening of the proper size to receive the dormer should be framed in the roof, and the studs of the dormer should be

notched out one inch over the roof boarding and trimmer rafter and extended to the floor. Notching the studding onto the roof prevents the roof from sagging or breaking away from the sides of the dormer and thus causing a leak, and the studding being extended to the floor also stiffens the trimmer and gives a homogeneous surface to lath on, without fear of plaster cracks. An enlarged section through the dormer sill is also given in Fig. 147 showing the way in which the flashing should be placed. The flashing should be laid over the second shingle and the third shingle laid over it. This keeps the flashing in place and looks better. The upper edge of the flashing should be securely nailed to the back of the sill. As soon as the walls of a frame building are up they should be covered with hemlock, spruce or pine boards, dressed one side and free from shakes and large knot holes. When the brace frame is used it is generally customary to sheath the first story before the second story studding is set up. The sheathing or boarding should be nailed at each bearing with two ten-penny nails, although eight-penny nails are often used. If the building is built with a balloon frame it is necessary to put the boarding on diagonally in order to secure sufficient rigidity in the frame. With the braced frame diagonal sheathing is not necessary, although it makes a better job than when laid horizontally, and all towers, cupolas, etc., should be sheathed in this way.

In covering the roof two different methods are pursued, in the first the roof is tightly covered with dressed boarding, like the walls, and in the second narrow boards are nailed to the rafters

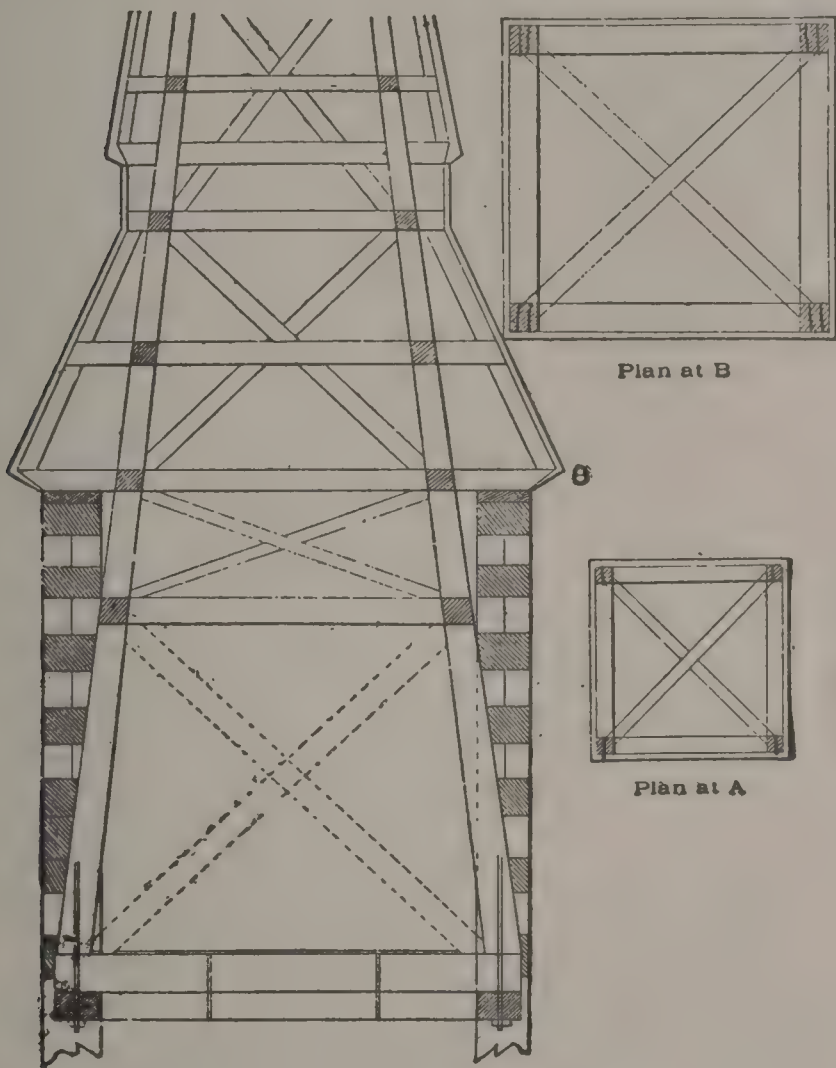


Fig. 148.

horizontally and with a space of two or three inches between them. The latter method is considered to make the more durable roof, as it affords ventilation to the shingles and causes them to last longer. But if the attic is to be fin-

ished such a roof is very hot in summer and cold in winter, and most architects prefer to cover the roof with boarding laid close together and then lay tarred paper over the boarding and under the shingles or slate; this not only better protects the attic space from changes in temperature, but also prevents fine snow from sifting in under the slate

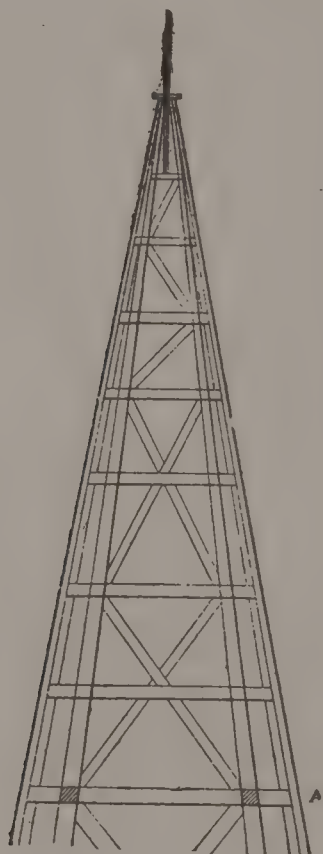


Fig. 149.

or shingles. The specifications should distinctly mention whether the boards are to be laid close together or laid open, as well as the kind and quality of the boards.

Tinned roofs should be covered with matched boards, dressed one side, and all holes covered

with sheet iron, and the ridges planed off. Figs. 148 and 149 show how a village church spire may be constructed by the use of scantlings 2x6 and 2x8 inches. The corner posts are formed of three pieces 2x6 inches spiked together. The other heavy parts are formed in like manner. Plans of the structure are shown at A and B. Of course this style of structure can be changed and adapted to suit almost any style of spire or tower; but it is not my intention to give many examples of spires, roofs, towers or steeples in this part, as I intend to show a number of such in Part 2 of this volume. I will, however, add a few light timbered examples, as they may be considered as balloon framing.

In the formation and construction of an ogee roof, many things are to be considered, and as many of these roofs are built up of light timbers and covered with thin and flexible materials it will not be considered out of place to notice a few examples at this point. Fig. A 150 shows a quarter plan A B of the timbers of an ogee roof to a circular tower. The three purlins also shown in the plan are marked 1, 2, 3, in the elevation. The division for the boarding on the outside is indicated by C D, that for the inside boards being indicated by G H, while intermediate bearers for additional fixing for boarding are numbered 4 to 8 in the elevation. Some of these bearers may be omitted at discretion. Fig. B 150 shows elevation and vertical sections of the wall plate, which is

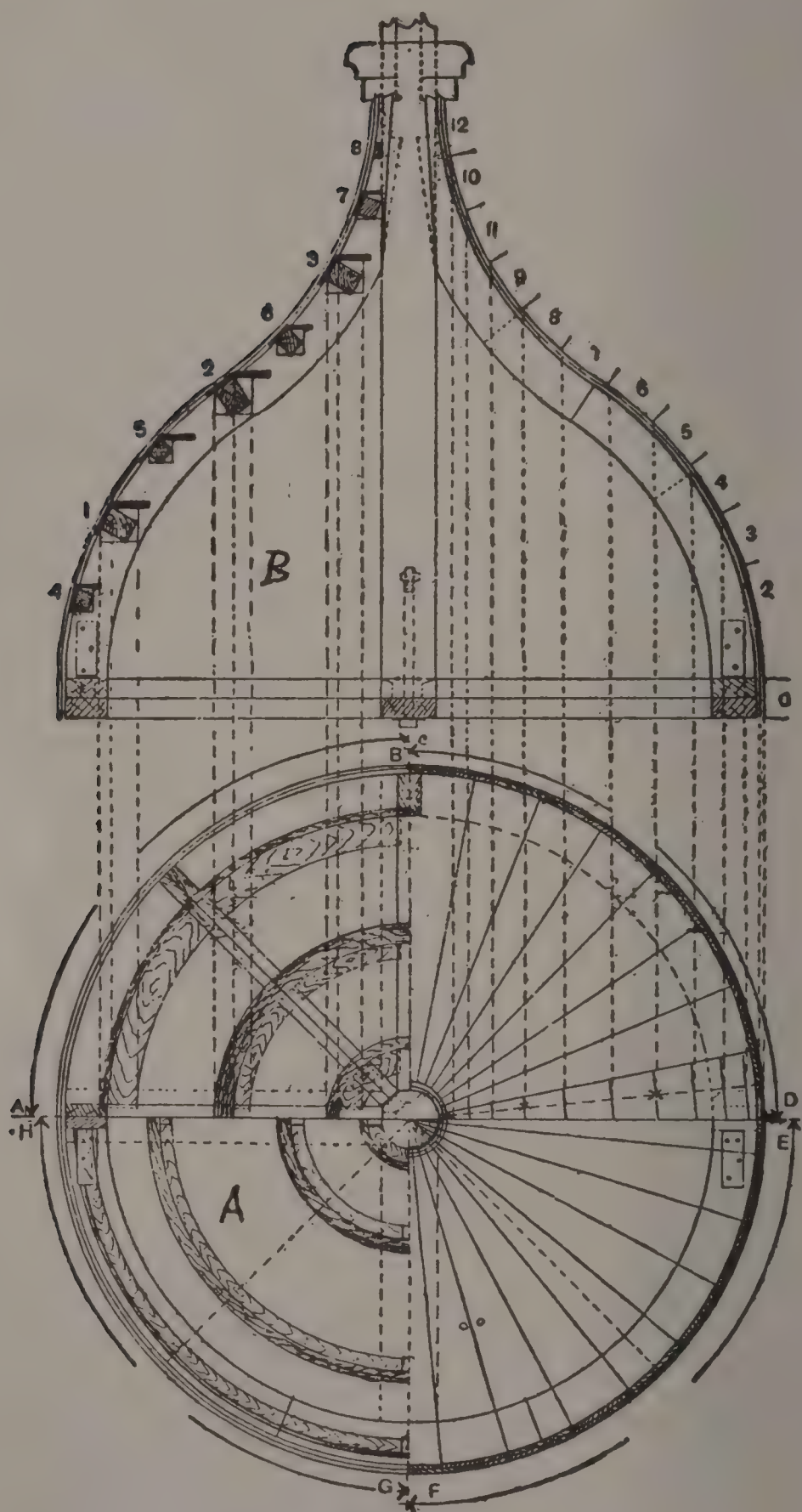


Fig. 150.

formed of two pieces, each 2 in. thick by $4\frac{1}{2}$ in. wide, with joints crossed, and having crossed bearers out of 6 in. by 4 in. stuff, halved together at the center and at the plate; all being flush both sides and securely bolted to the plate with $4\frac{1}{2}$ in. by $\frac{1}{2}$ in. bolts. The center post is out of 6 in. by 6 in. octagonal stuff, is stump-tenoned into the bearer at the foot, and secured with 1 in. bolts. This post may at option be carried up above the

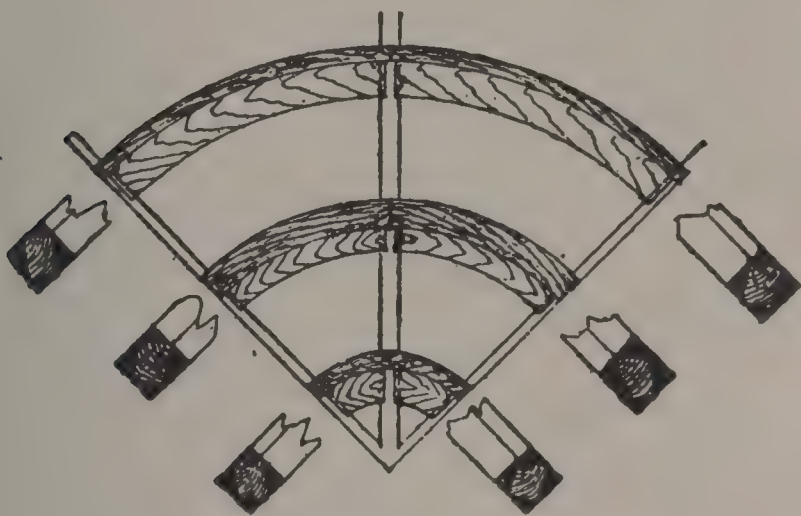


Fig. 151.

cap, and finished with ornamental turned or octagonal worked finial. The ogee rafters are $4\frac{1}{2}$ in. wide and are made up of two $1\frac{1}{4}$ in. thicknesses. The joints are crossed and securely fixed together with screws or clenched nails, are stump tenoned into the plate at the bottom, and are shouldered into the post at the top, as shown by the solid line, and stump tenoned as shown by dotted lines (see section Fig. B).

The rafters are secured to the plate at the foot with angle irons 6 in. or 8 in. long by $2\frac{1}{2}$ in. or 3 in. wide and $\frac{1}{4}$ in. or $\frac{3}{4}$ in. thick, fixed with $\frac{3}{8}$ in. coach screws or bolts. Purlins 1 to 3 are the main purlins. Additional purlins 4 to 8 may be introduced if necessary. Dotted lines carried down from section to plan show the length required, and the section Fig. 155 shows the size of stuff required for cutting. Fig. 151 shows the main purlins (1



Fig. 152.



Fig. 153.

to 3) for one-quarter; the sections, and the surplus stuff to be cut away, being shown by black shading. These purlins can be cut out of 4 in. by 9 in. deals, and with very little waste of material if the inside (commonly called the belly) is cut out first and glued on the back edge, two ribs being thus got out of each 9 in. deal.

Fig. 152 shows the intermediate purlins or bearers for one-eighth of the circle. Moulds are taken from the plan in the same way as for the

main purlins, and the bevels for squaring are obtained in the same way in each case. Fig. 153 shows (looking upwards) the turned cap, perforated to allow of sliding on to the octagonal post. The shape of the outer thickness of the cover boarding is shown by Fig. 154. The method of obtaining the mould for these boards is as follows: First, divide the quarter C to D into the same number of spaces as the predetermined number of boards to be used. Next, divide, on the outside, the line of covering into say twelve equal spaces—the more spaces the greater the accuracy (see section numbered 0 to 12). Lay out these spaces in a straight line (see Fig. 154) to get the stretch-out of the ogee from the back of the ogee (see the dotted lines on the plan), carry down a line to the center of one of the boards on the quarter (see X X). Take in the compasses the width of the board each way from the center, and transfer these widths on the stretch-out line as Fig. 154. Trace the widths from point to point, and the necessary mould will be complete. Let the mould be of the full given width. To allow for the slight difference made by the curve of the board, the joints will be slightly wreathed. This wreathing may be accurately obtained by following for the lower thickness the same instructions given for the upper, when the difference in the widths of the two boards will give the wreathing necessary. The boards, for convenience of bending, may consist of two

thicknesses of $\frac{3}{8}$ in. of $\frac{7}{16}$ in. stuff; if $\frac{7}{8}$ in. that thickness has been specified. In fixing, let them lap over the joints by allowing the center line of the lower board to be the joint line of the upper board. Fig. 155 shows the inner edge of the rafters, with



Fig. 154.

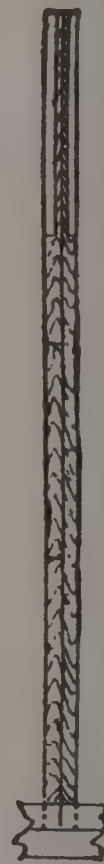


Fig. 155.

their joints and tenons. Circular towers in framed construction may be divided into two classes, namely, those which have their foundations on a line connected with the main foundation of the

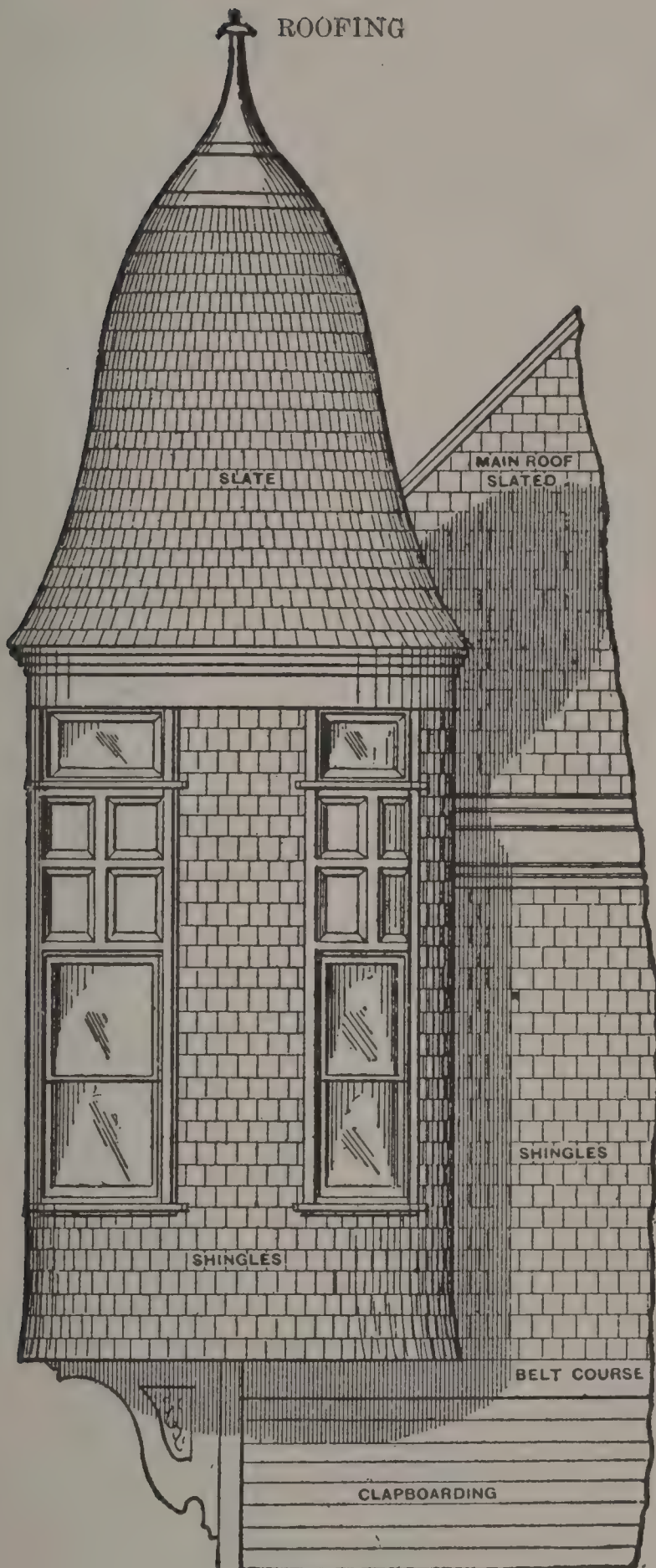


Fig. 156.

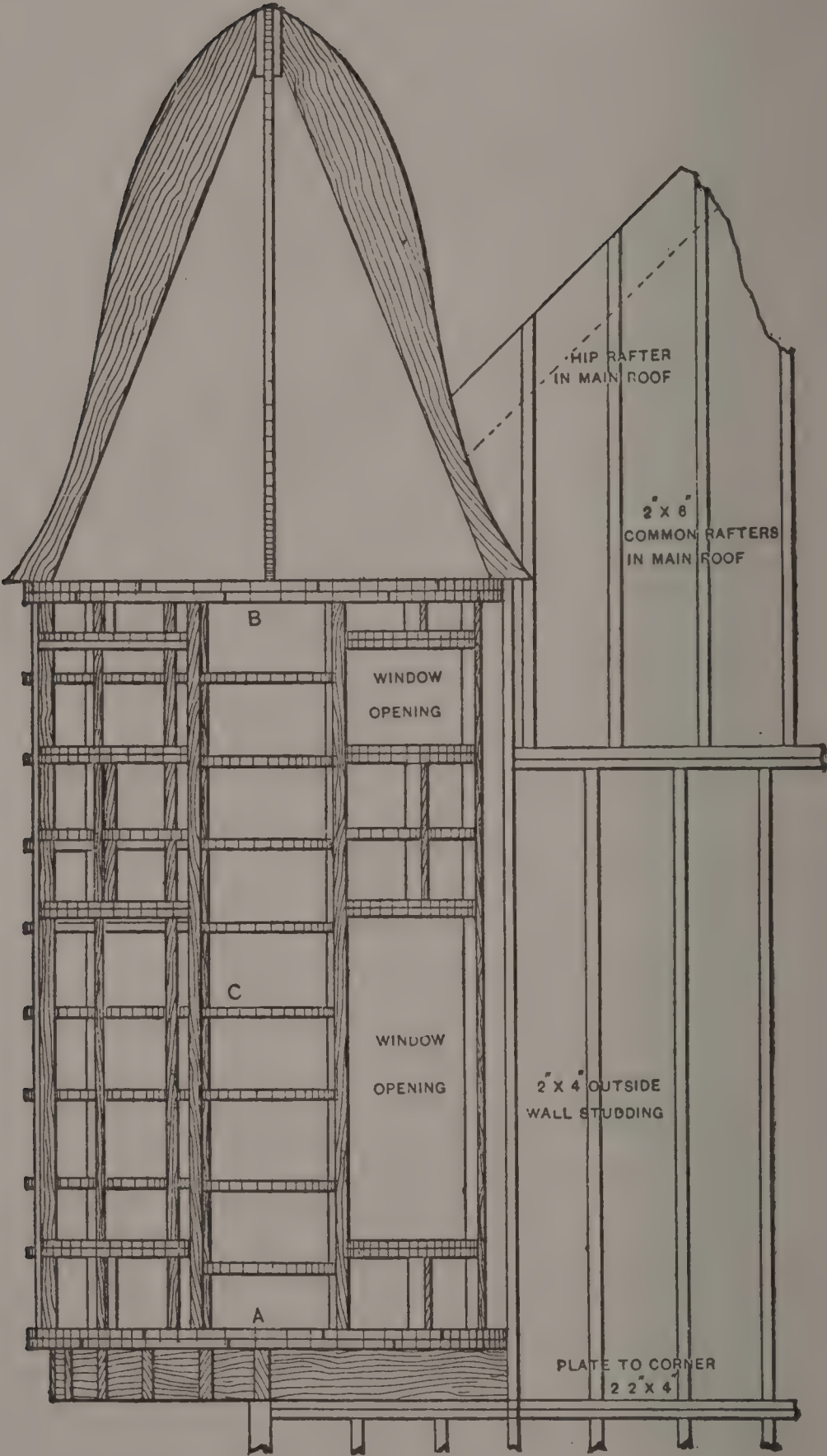


Fig. 157.

house, and second those which are carried up from the second floor, resting on, or being supported by, the floor beams of the second story. The latter class will be considered, as it embodies more important construction, although some of the matters which will be treated are applicable to all circular

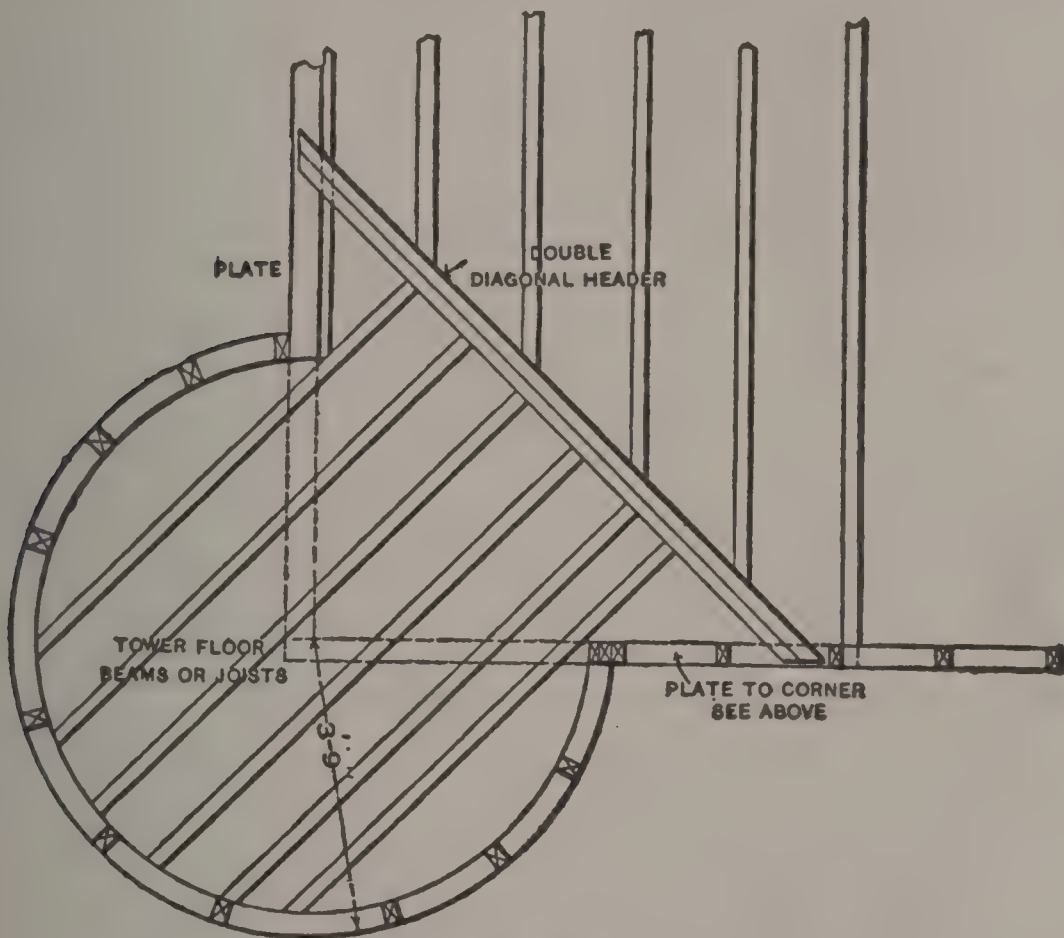


Fig. 158.

towers. The first thing for the practical carpenter or builder to consider is how to so construct the floor as to support the tower in a proper manner; that is, so that it will sustain with perfect safety the weight to be placed upon it.

Referring to Fig. 156, which is supposed to rep-

resent the general appearance of a tower built on an angle to a house. It is placed at the right hand of the front of the building, and is designed to form an alcove closet, or an extension to the corner room. Its plan, as may be seen in Fig. 158, is a three-quarter circle, the apex of the angle at the corner being the center from which the circular plan is struck. The radius of the plate outside is three feet nine inches thus making the tower 7 feet 6 inches in diameter. It is intended that the tower floor shall be level with a room in the second story and the beams or joists must be framed in such a manner that the flooring can be laid in the circle of the tower, while at the same time being so secured as to support the weight of it. The form of construction indicated in Fig. 158 of the engravings is well adapted for the purpose, and an inspection will show that it consists of a double header made of 2x10 inch timbers placed diagonally across the corner at a sufficient distance back from it to give ample leverage to counterbalance the weight suspended outside the plate. The tower beams are framed square into this header on the outside and the floor beams are framed into it on the inside. By this construction a cantilever is formed, for the header in carrying the main beams forms a counterpoise for the superadded weight, which is borne by the unsupported beams which project outside. It will be readily seen that this, obviously, is a good construction, and

much better than introducing many short timbers after the manner indicated in Fig. 159. In the latter case the leverage outside being much greater than that inside, the plate being the fulcrum, there is a strong probability of its tearing away from the main framing. For the same reason it is regarded as a serious mistake to attempt to

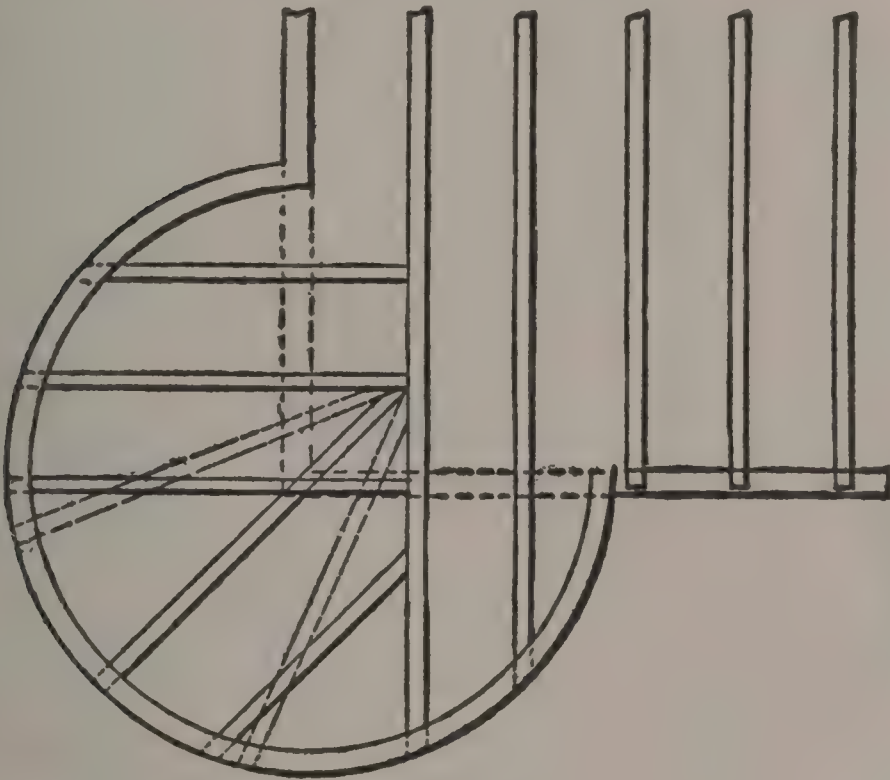


Fig. 159.

radiate the timbers as indicated by the dotted lines in Fig. 159. The position of the timbers are shown in the elevation of the framing, Fig. 157, and we have no doubt that practical builders will fully appreciate what has been pointed out.

When the beams are inserted and the main framing has been nailed, a bottom circular plate,

or template, marked A, in Fig. 157, is made from two thicknesses of 1 inch stuff, and nailed on exactly the size required. The position of the window studs is also marked on it, as represented in Fig. 158. The upper plate, or which is really the wall plate proper, and indicated by B in Fig. 157 of the engravings, must also be made, and this will rest on the top ends of the studding and support the rafters. This plate will be a complete circle measuring 7 feet 6 inches in diameter and struck with a 3 foot 9 inch radius rod and laid out upon the floor, as indicated in the roof framing plan, Fig. 160. The pieces necessary to form the upper and lower plates may be sawn out of rough 1 inch pine boards from one pattern, which may be any one of those drawn in the plan, and a number of which go to make up the whole plate. The studding are cut 11 feet 8 inches, which being added to 4 inches, the thickness of the plates, makes the entire height 12 feet. The window headers, both at the top and bottom are likewise circular and are framed in after the manner represented in Fig. 157 to form the openings and cripple or short studding cut in under them in the center. All studding must be set perfectly plumb and all plates and headers perfectly level. In order to insure this it is well to be certain that the bottom plate is level by placing a parallel straight edge with a spirit level on top of it, across the plate at different points. Then, if the studding be cut in equal length

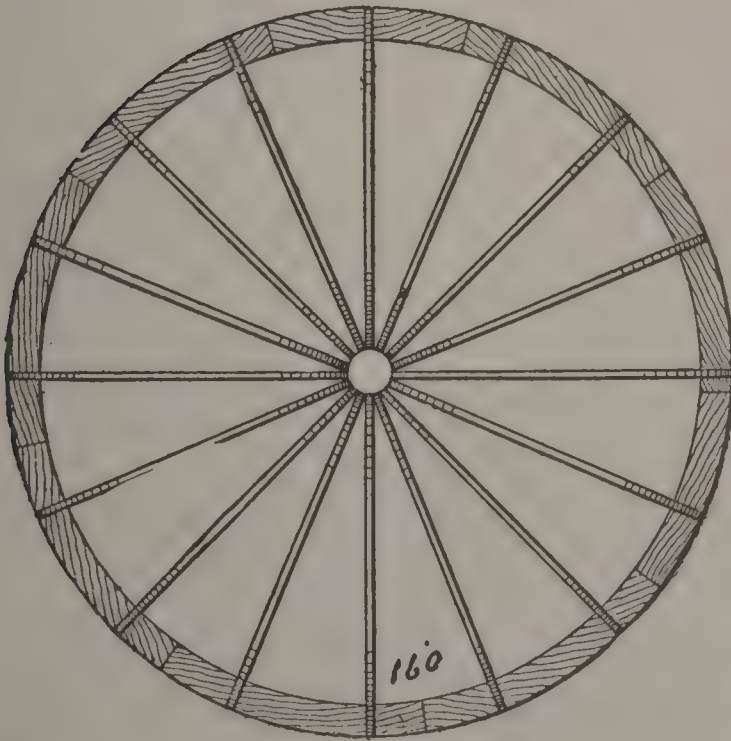
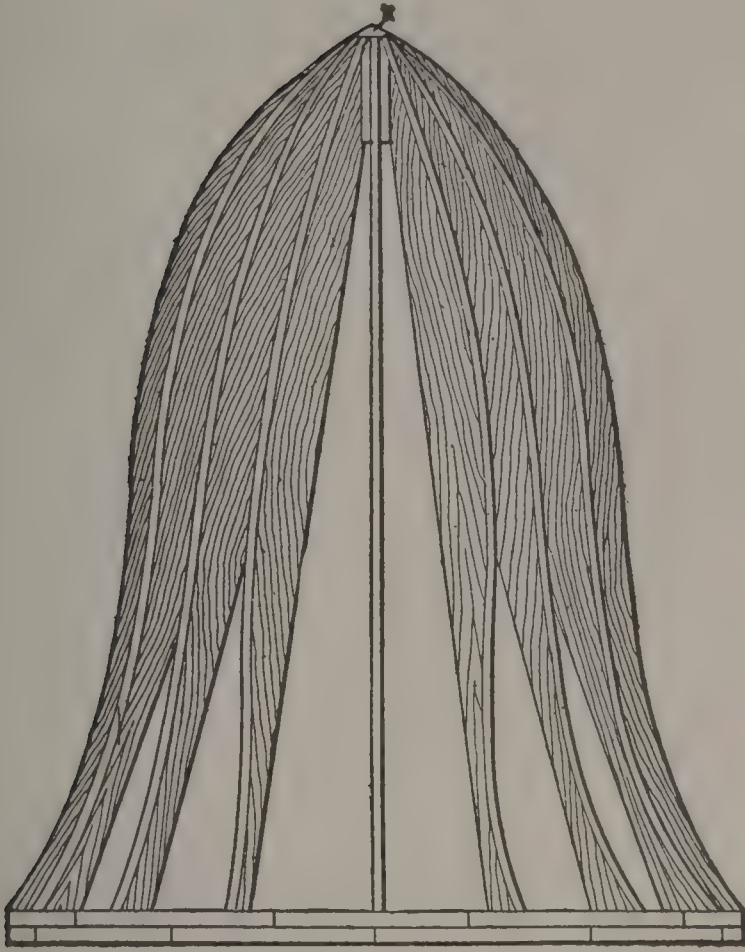


Fig. 160.

the upper plate must, in consequence, be placed in a level position. A number of horizontal sweeps, 2 inches thick and 4 inches wide, as indicated at C, in Fig. 157, require to be cut out to form ribbing or pieces nailed in 16 inches apart, to which the vertical boarding outside and the lath and plaster inside are fastened. It will be seen that if this construction is followed the whole cylindrical wall can be very strongly and economically built up. To save time and labor and also to expedite matters, the sweeps may be sawed out at the mill with a band saw, although it can be done in pine with the compass saw.

With regard to the molded roof, it may be said that having a molded outline it will necessarily require molded rafters sawn to the curvature called for in the elevation. As a general thing, architects furnish a full size working detail for roofs of this kind, but it often happens that it is not forthcoming and the carpenter or builder is obliged to strike out a pattern rafter himself. To do this quickly and as accurately as possible, it is well to lay out the whole roof on a floor, something after the following manner: Referring to Fig. 161, draw any base line 7 feet 6 inches in length, as A B, and divide exactly in the center, or at 3 feet 9 inches, as C. From C square up the line to 9 feet high, as C D, and divide this line into 13 equal divisions, as 1, 2, 3, 4, 5, 6 etc. Through these points draw lines parallel to A B or square C D

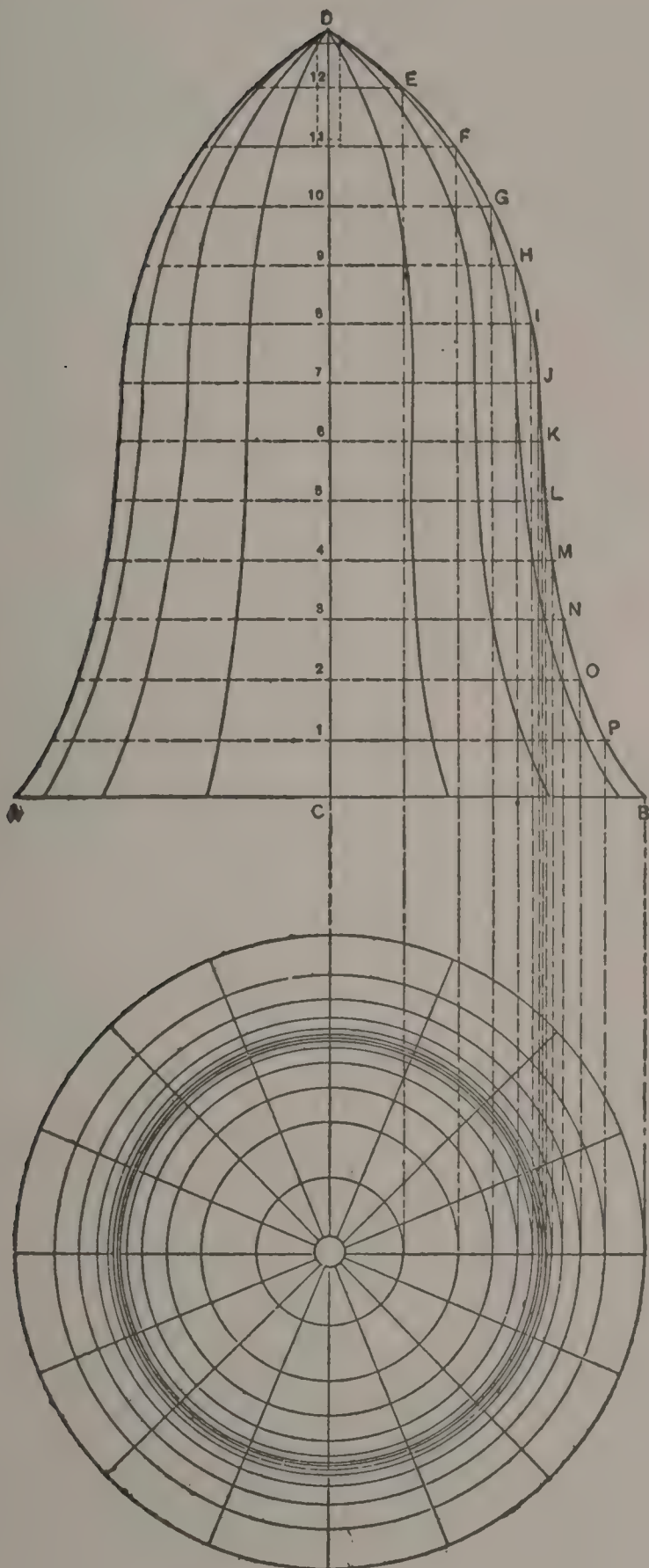


Fig. 161.

any length on each side of C D. Now, from the point D dress the curve of the rafter, as indicated by the letters E, F, G, H, I, J, K, L, M, N, O and P, as near to the outline as possible. A very good method of obtaining these curves is to divide the architect's 4 inch scale drawing by horizontal division lines similar to those in Fig. 161, and to scale off the lengths from the axis or vertical line C D. By setting off these measurements on a full size lay out, points will be obtained through which the flexure of the curves may be very accurately determined.

The 16 rafters may all be drawn from the one pattern, as they are all alike and should be framed to fit against a 3 inch wood (boss), as indicated by X in Fig. 160, in order to obtain a solid nailing at the peak. In this engraving rafters are shown in position in elevation and also in plan, as well as the way they radiate or are spaced around the circle 16 inches apart on the plate. As it is always best to board such roofs as this vertically, ribbing or horizontal sweeps will have to be cut in between the rafters, and as there should be as many of these as possible for the purpose of giving a strong framework to hold the covering boards, it is advisable to cut in one at each of the divisions marked on the elevation shown in Fig. 161. The outline plan of this figure represents the top lines of these sweeps, which are well nailed in between the rafters. Fig. 162 of the engravings shows the

exact size of the headers and their positions when nailed in. They are struck from different radii, which shorten as they go upward. It will be noticed that each set of sweeps is consecutively numbered with the lines C 1, 2, 3, etc., from C to D of Fig. 161. There will be 15 sweeps in each

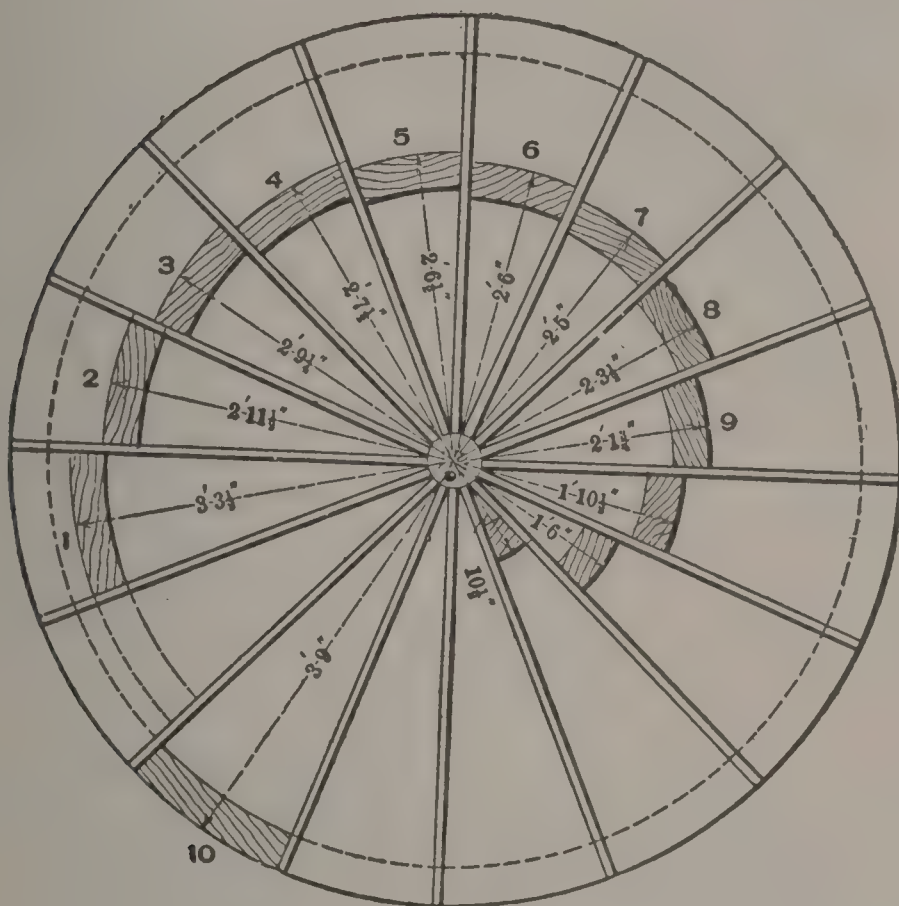


Fig. 162.

course and, therefore, 15 different patterns. They may be conveniently numbered and marked in the following manner: For No. 2, for example, a pattern can be cut and marked "Pattern for 15 sweeps, No. 2." There will, therefore, be 180 altogether to be cut out, and these should be cut

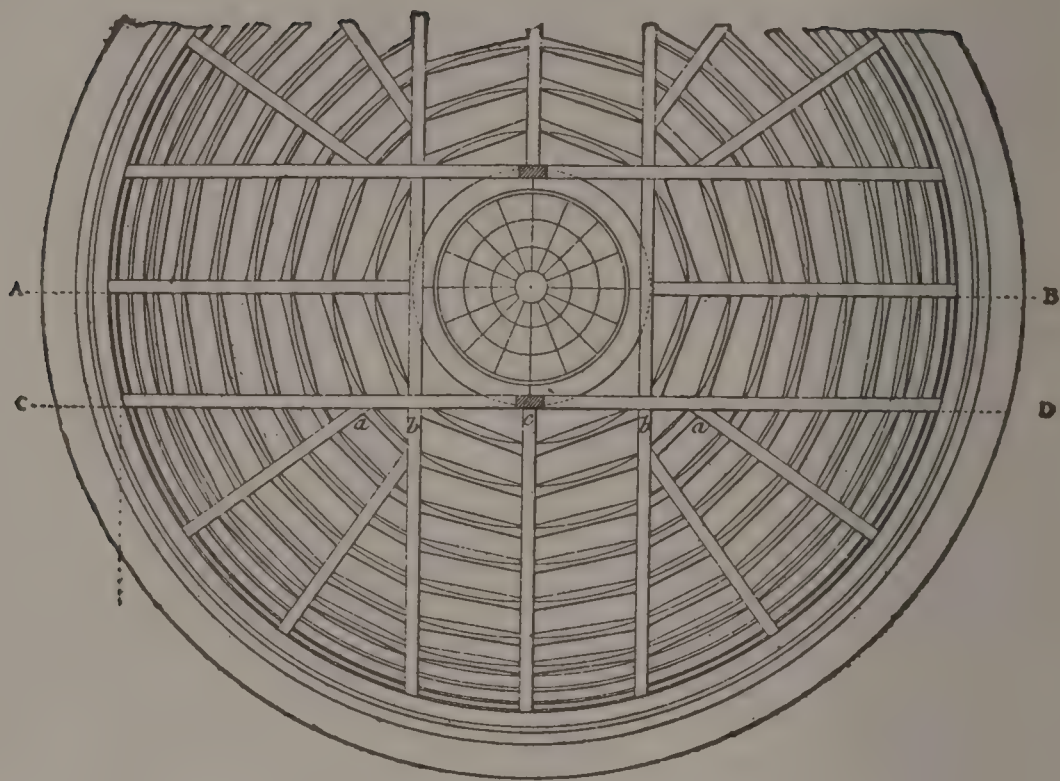


Fig. 163.

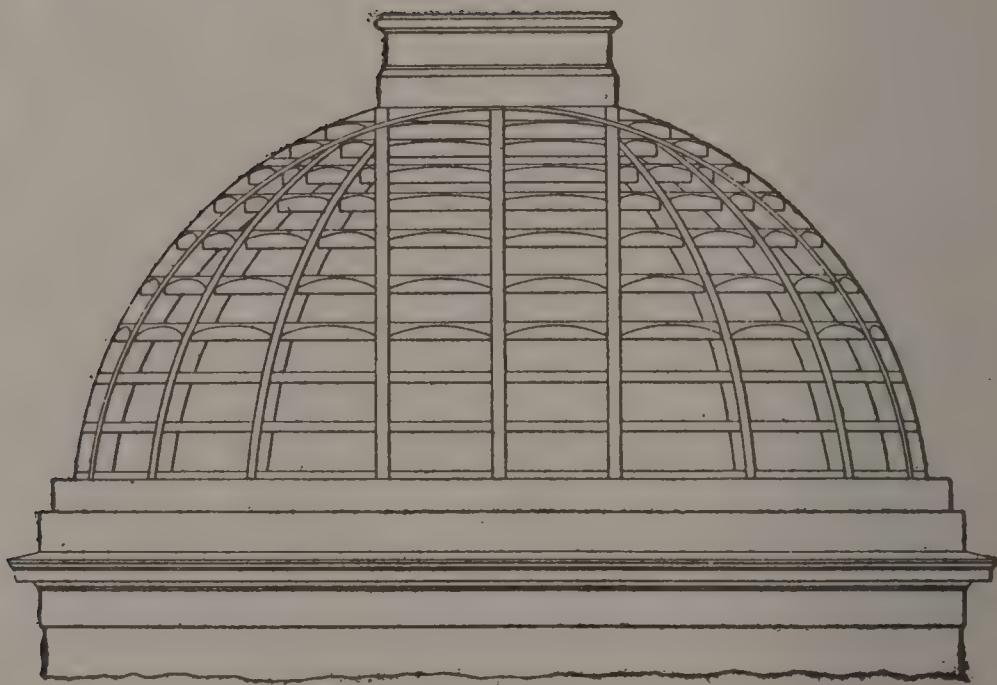


Fig. 164.

a trifle longer than the exact size, in order to allow for fitting.

At Figs. 163 to 166, I show the construction of a domical roof with a circular opening in the center for a skylight. Two of the main principals, C D and the corresponding one, are framed with a king-post *c*, as shown in Fig. 165; the others at

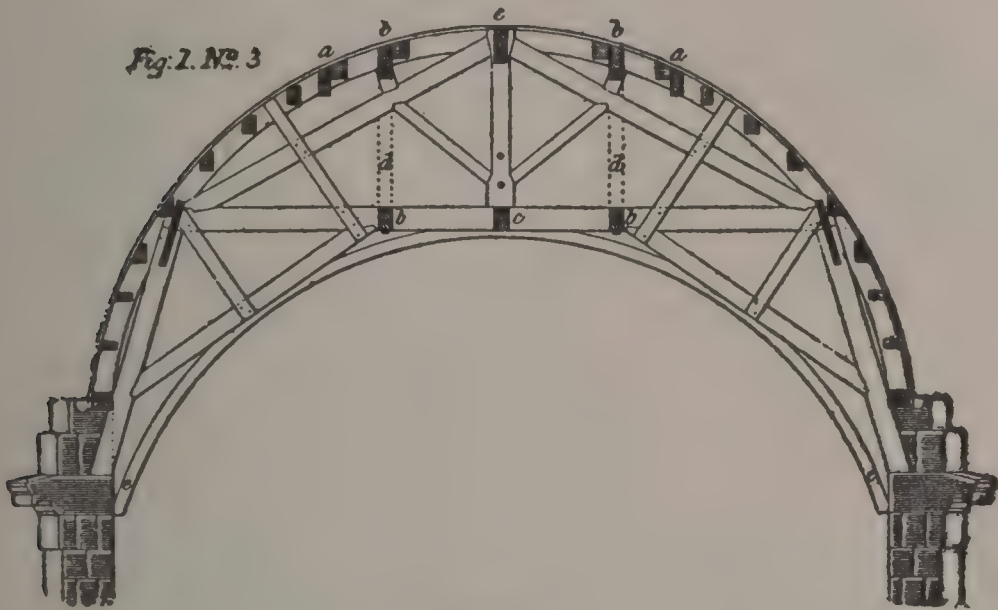


Fig. 165.

right angles to these, with queen-posts, as seen in Fig. 166. The main ribs correspond to the principals, and the shorter ribs are framed against curbs between them, as at *a* Figs. 163 and 165.

Figs. 167 and 168 show the framing of an ogee domical roof on an octagonal plan. The construction will be readily understood by inspection; and the method of finding the arris ribs, shown in Fig. 169 will be understood from what may be said when treating of hip-rafter.

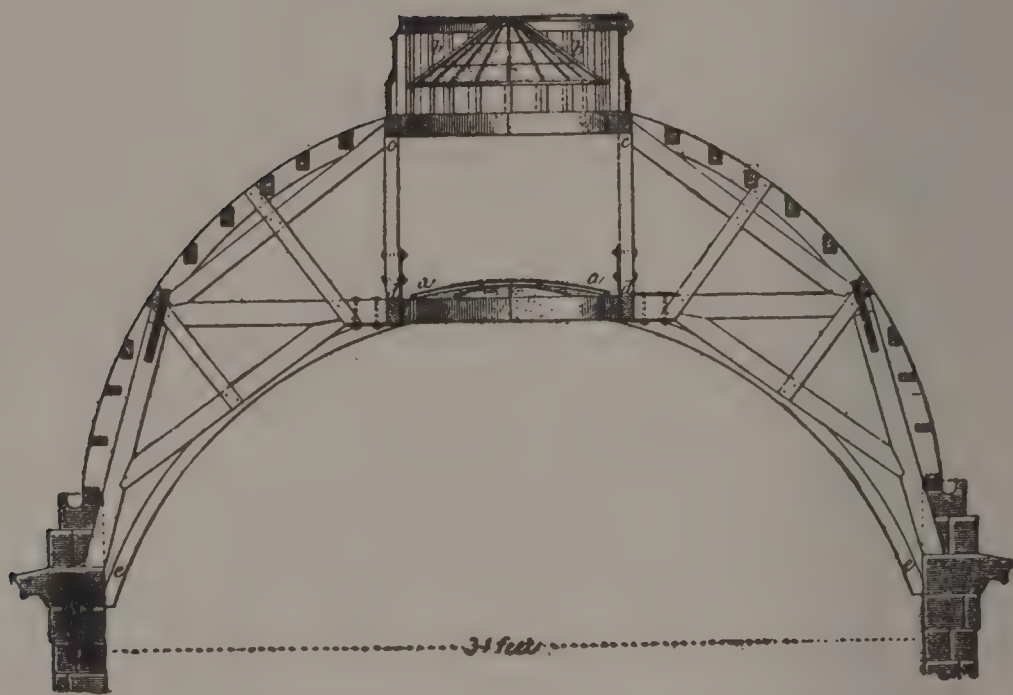


Fig. 166.

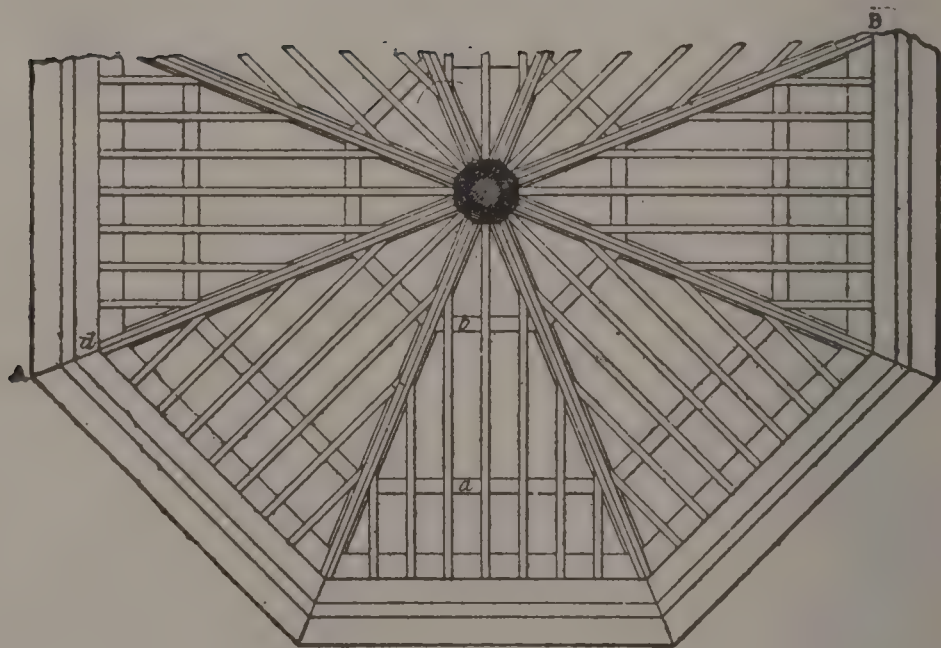


Fig. 167.

Figs. 170, 171, 172 and 173 show the construction of a domical roof with a central post *b*, Fig. 172, into the head of which four pairs of trussed rafters are tenoned; four intermediate trusses Fig. 173, are framed into the same post at a lower

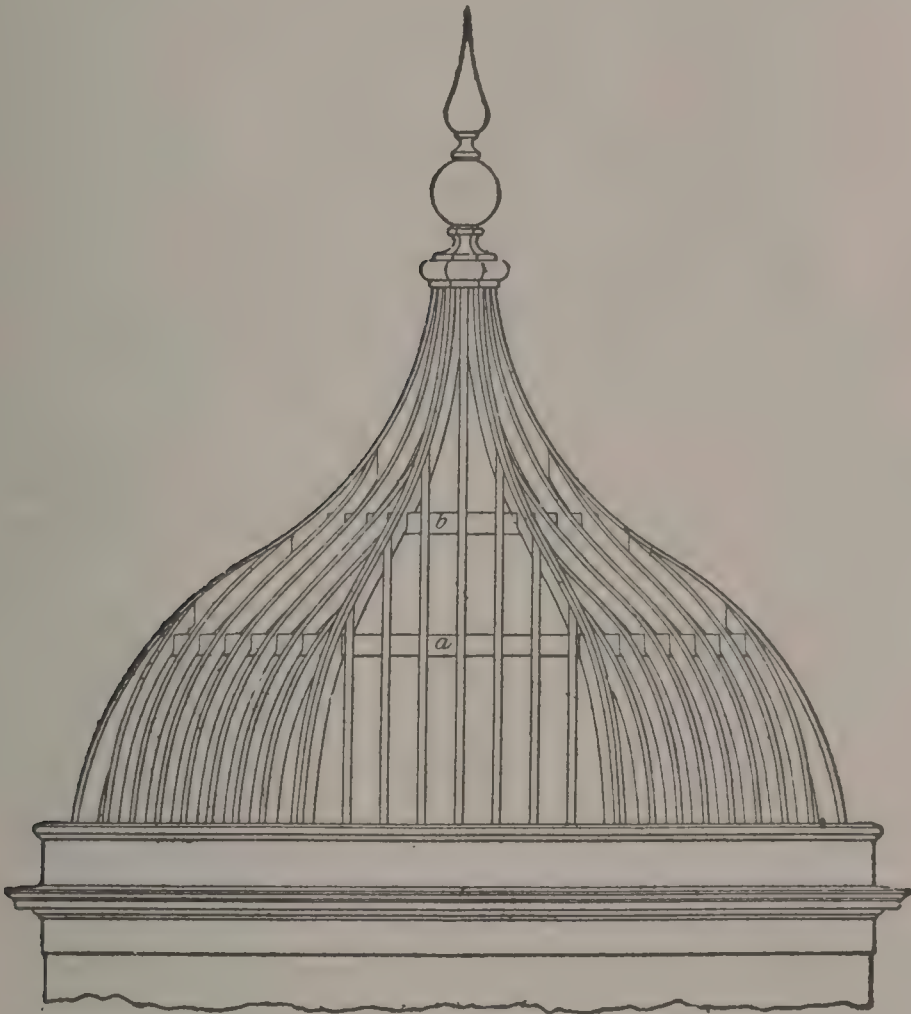


Fig. 168.

level. The collars are in two fitches as shown at *c* Fig. 172, and are placed at different heights so as to pass each other in the middle of the span. The collars of two trusses at right angles to each other may be on the same level, and halved together at

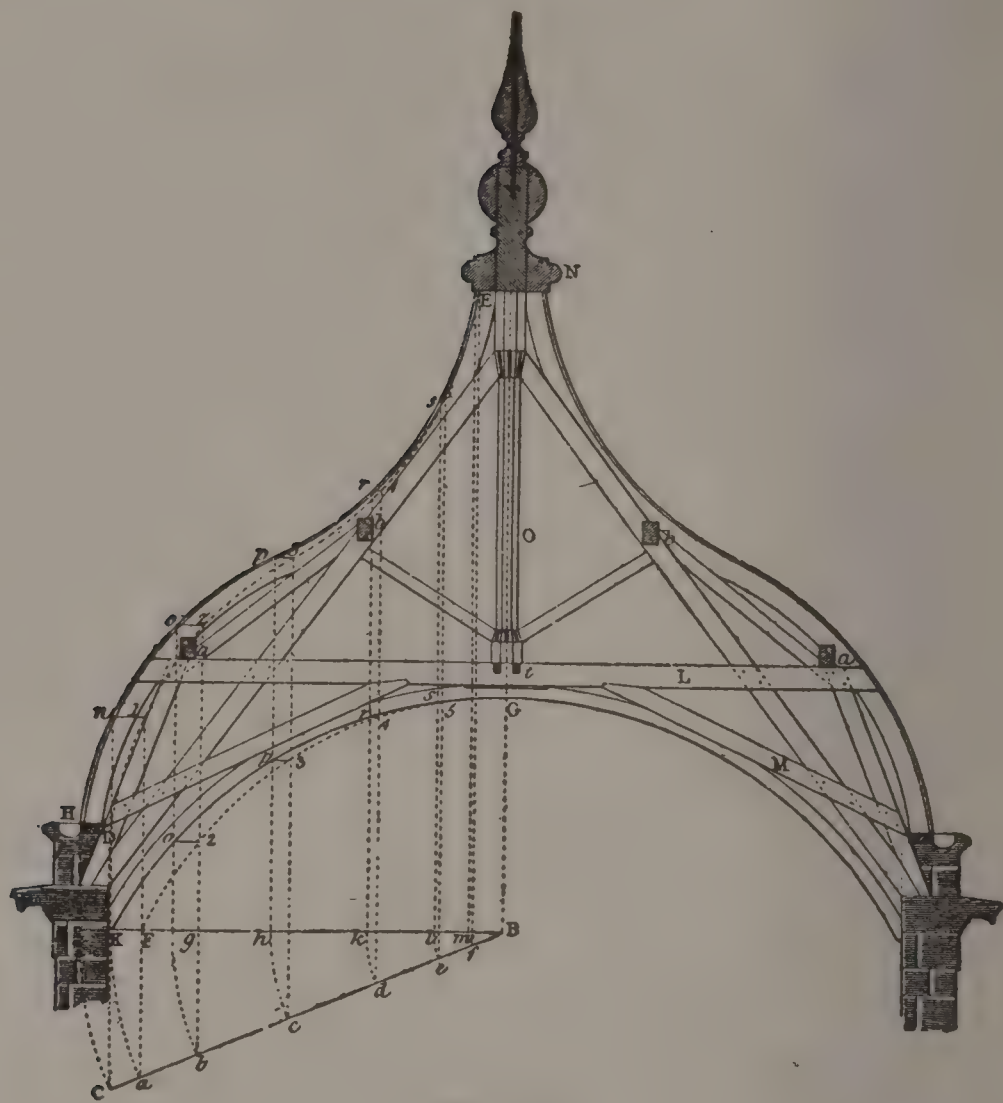


Fig. 169.

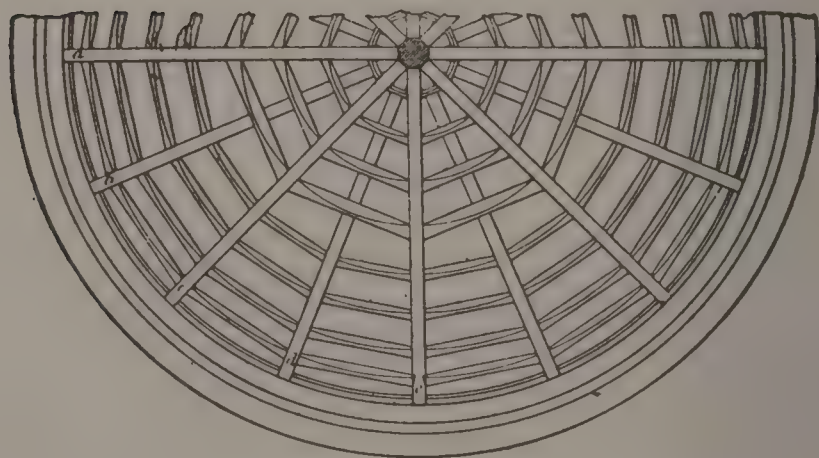


Fig. 170.

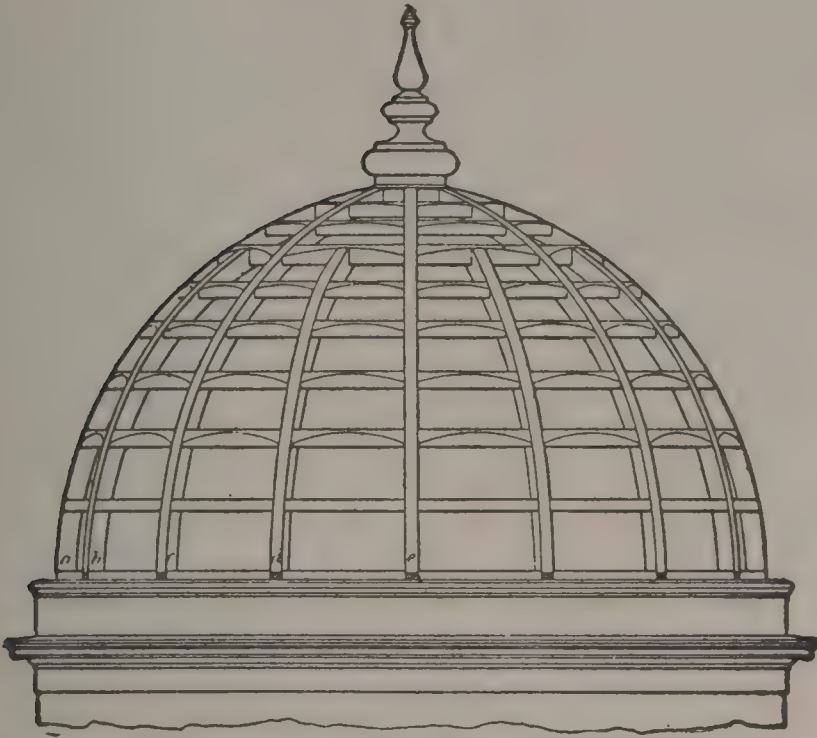


Fig. 171.

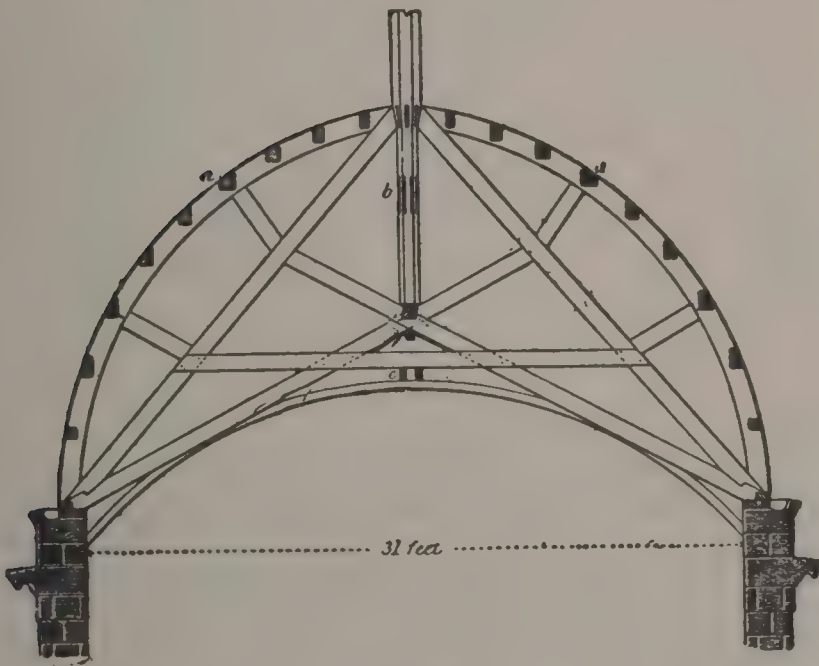


Fig. 172.

their intersection, as shown at Fig. 173. The curved ribs are supported by struts from the principals, as seen in Figs. 172 and 173. The plan and elevation Figs. 170 and 171 exhibit the curved

arrises which the sides of the horizontal ribs assume when cut to the curvature of the dome, as at *a* Fig. 172.

In connection with these domical or curved roofs it may not be amiss to give a few examples of the methods by which the various curves are obtained for the hips and cripples or jack rafters, that are to cut in against the hip. Generally, the major or regular rafter, will be cut on an irregular curve,

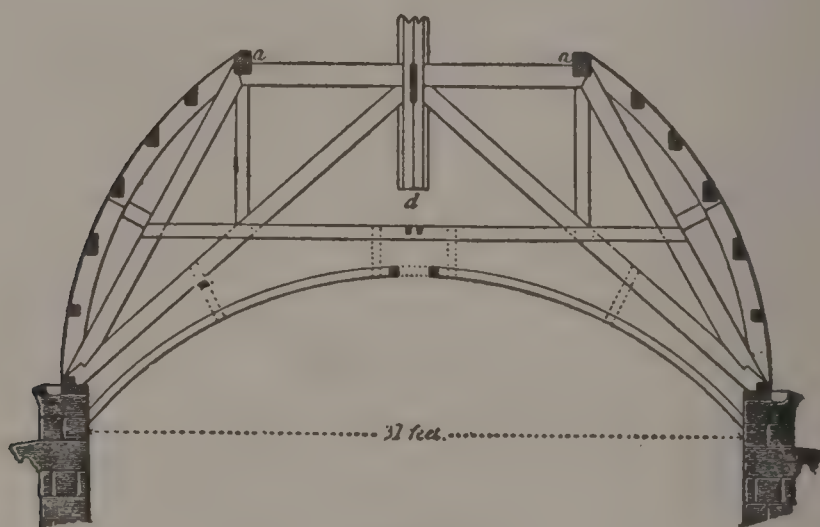


Fig. 173.

or elliptical as will be seen at Fig. 174 this sketch, the dotted curved line from *A* to *g* represents one method, while the curved line between the two points following the intersections of lines at *A b c d e* and *f* with horizontal lines *H I J K* and *Y*, must be the exact position for the major rafter at each of these points. More points may be taken in the same manner, according to the requirements of the case. The major rafter can be taken in this

manner from any shape that it may be desirable to employ in the minor rafters.

Another example is shown at Fig. 175. Here the common or major rafter is laid down first, then



Fig. 174.

mark the seat of the hip rafter and draw in the ordinates, as shown by the dotted lines, and employ as many as seems desirable, the number being immaterial. Extend them downward until they cut

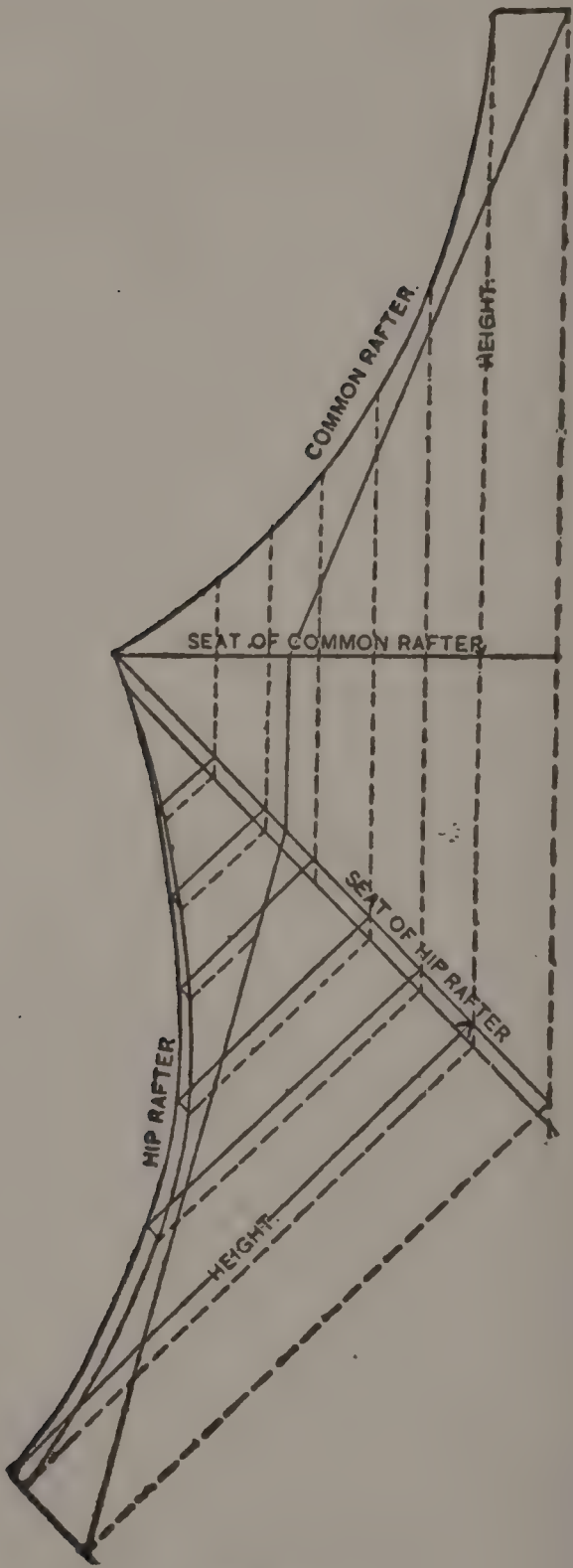


Fig. 175.

the seat of the hip rafter. Square out from the seat, and make the different heights measured from it correspond with the lines from which they are derived. Then take a thin batton strip and bend it to suit the points thus established. Mark in around the batton. This will give the true shape of the hip rafter. Now lay off half the thickness of the hip rafter, parallel with the seat as shown, and where the ordinates cut it, square out, as shown by the dotted lines. Also square out with the ordinates in the hip. Draw in the short lines cutting the sweep and the dotted ordinates. This gives the required backing, as may be seen by the dotted sweep. In the third place, to more thoroughly understand why all this should be, take a piece of large cove molding as shown in Fig. 176, then cut one end square and one end a miter and square down the ordinate as seen on the square sections. Carry the lines along the bottom of the piece, and square them again across the miter section. When this has been done, let him see if it will fit a true circle. Let me here remark that when any circular body is cut on an angle the section ceases to be round and becomes elliptical. This is a fact well worth keeping in mind. There are many other methods of obtaining curves for this kind of work, and when I come to discussing heavy timber framing and roofing, I may take the subject up again.

In the framing of mansard and curb roofs with

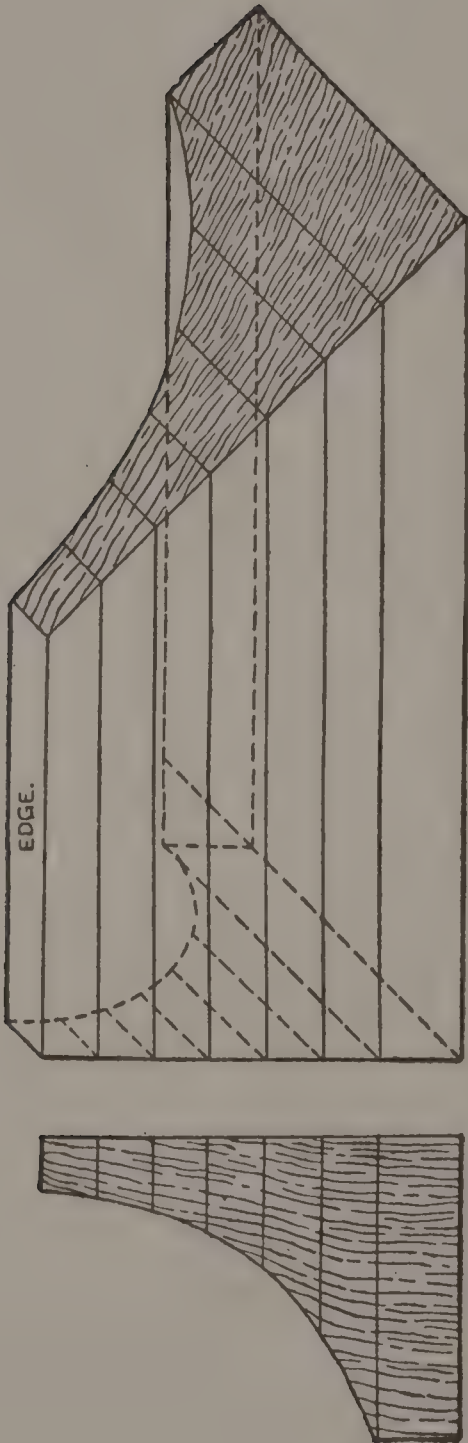


Fig. 176.

light scantlings, many methods are in vogue, some very good, some otherwise. I will have more to say on this subject, too, later on. The method I

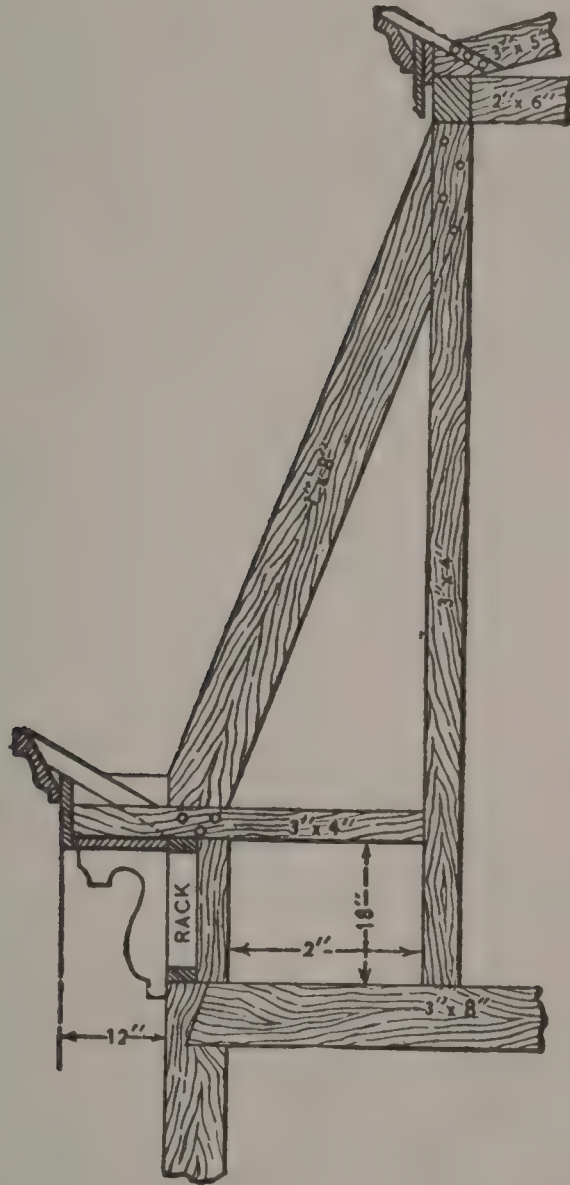


Fig. 177.

show here at Fig. 177 should commend itself to all good framers, as being neat, strong and economic. It is built up with small timbers and is quite sufficient.

The two schemes for mansard roofs shown at Fig. 178, are in a measure self-explanatory. They are formed with light scantlings and joists, the

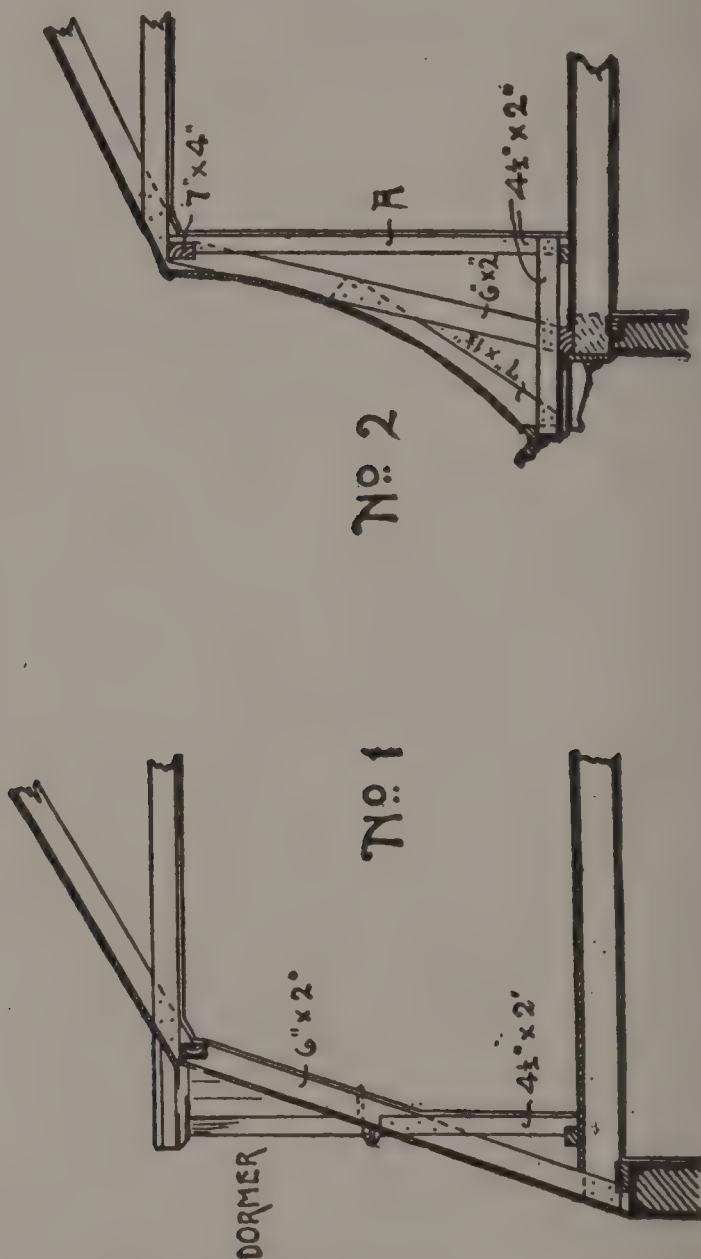


Fig. 178.

sizes of timbers being given on sketches. The joists of the attic floor serve as the main ties, and are spiked to the wall-plates. In No. 1 the common rafters forming the lower slopes of the roof are

nailed to the joists, and supported in the middle by studding. They are cut out at the top in bird's-mouth form to support the continuous plate, on which the upper rafters and ceiling joists rest. A more elaborate arrangement is shown in No. 2, where the lower slopes of the roof are curved, and an eaves cornice of wide projection is constructed. A partition is introduced at A, so that the walls of the rooms are vertical. For roofs of ordinary buildings, cottages, dwellings or even country villas the examples shown will be quite strong enough to do all service required of them. For larger and more extensive buildings, heavier and larger timbers will be required, and under the head of Heavy Timber Roofs in the second part of this volume, I will deal with mansard and other roofs at length.

For a light trussed roof, that is self-supporting, the German Truss, so called, for light stiff work, is an excellent arrangement. Fig. 179, shows the method of construction and Fig. 180, some details of same. This truss is generally known as the scissor-beam truss. Here the collar-beam is in compression, and the parts or timbers mostly being double as shown in details C and B. The rafters being supported in the middle are more than twice as strong as in a couple-close roof of the same span. The ends of the collars may be halved on to the rafters and secured with nails or bolts. A board may be clinch-nailed to unite the three pieces

at the apex. Trussed-rafter roofs of this and other kinds involving a considerable amount of labor,

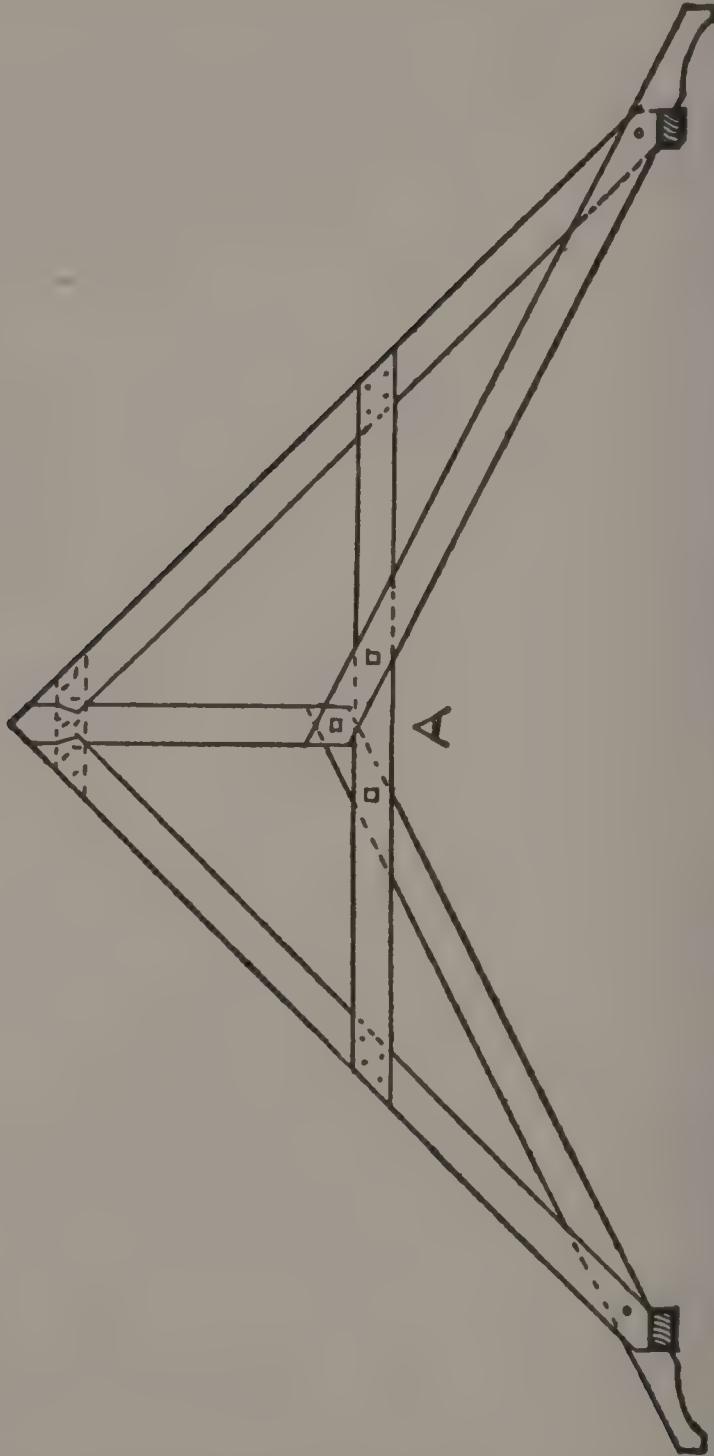


Fig. 179.

may, for the sake of economy, be spaced farther apart than ordinary rafters, stronger slats being

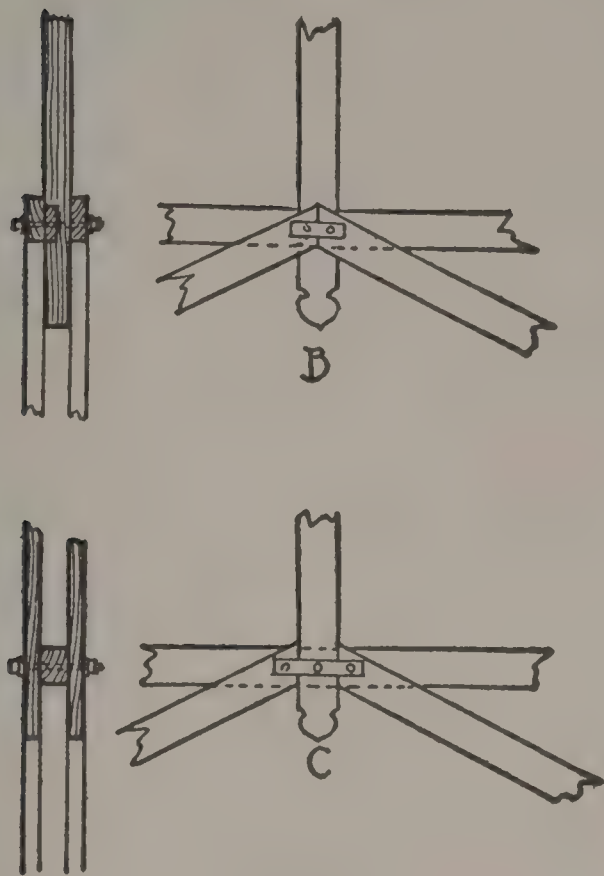


Fig. 180.

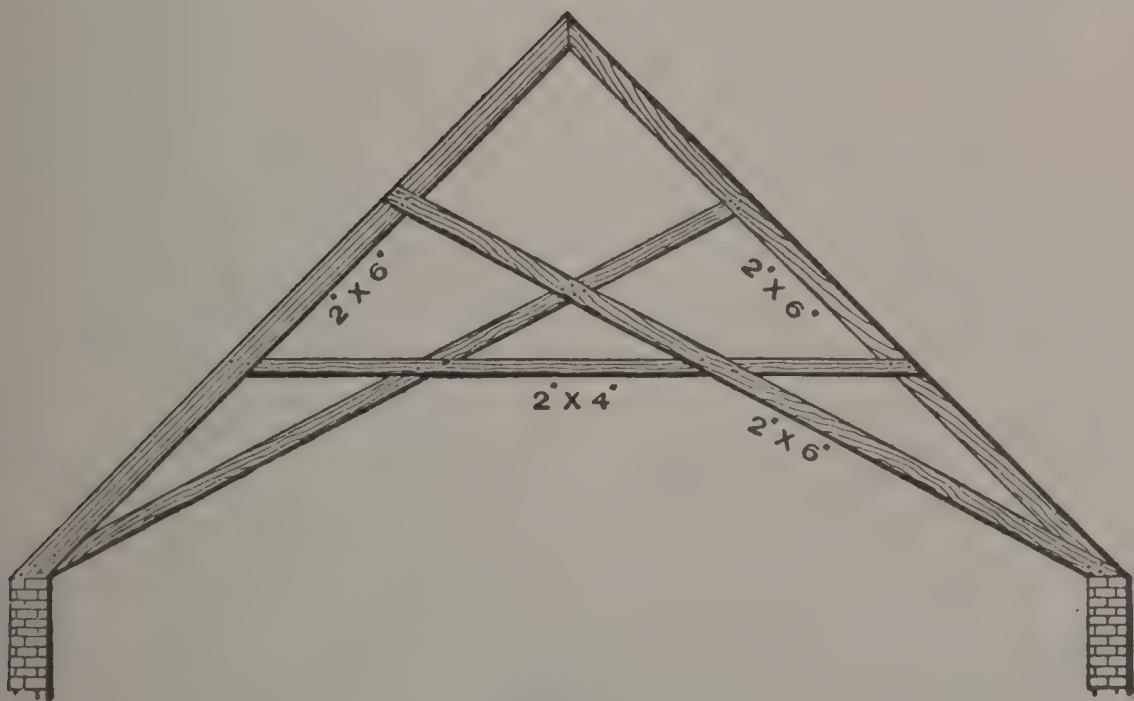


Fig. 181.

used for the slating, and furring strips being fixed to receive the plasterer's laths.

Another roof, somewhat similar to the one just shown, is exhibited at Fig. 181. This is more eco-

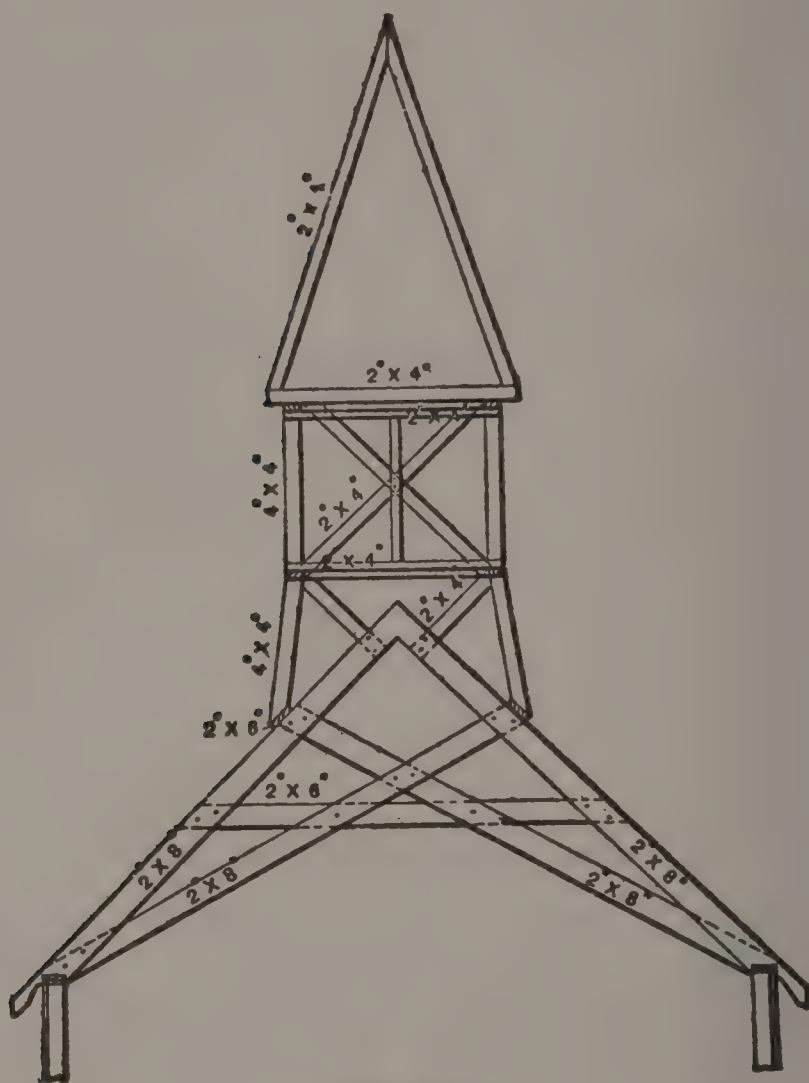


Fig. 182.

nomical than the previous example so far as labor is concerned, but is by no means as good or efficient, but will be found quite efficient where the span is not more than 30 feet; where the timbers cross each other they must be either well spiked

together, or have carriage bolts put through them and well tightened. It often occurs that the carpenter is called upon to build a ventilator or belfry on a stable or other building and in order to meet this emergency I submit the sketches Figs. 182 and 183, which I think will often prove useful. We suppose the roof to be already constructed and the upper work, as shown at 182, built over the ridge with very light timbers; Fig. 183 shows the ventilator and a portion of the stable in a finished condition.

Many bay windows are now built without having a foundation from the ground, the whole being projected from the wall of the building and a few hints and suggestions as to the construction of a window of this kind may not be out of place at this point.

In Fig. 184, is shown a detail of the manner in which the sills and joists in a house are built. The foundation wall is of cement, the sill of 2x8 inch material. The joists are 2x10 inch material placed sixteen inches on centers. On the plan where the bay-window comes the joists should be longer and should be extended past the wall eighteen inches, as shown in detail, Fig. 185. These joists support the bay. As a rule a templet is made from plan and is used to lay out window on joists and they are cut to conform with it. It is customary to spike on the ends of the joists pieces of the same material to strengthen the work. I have found

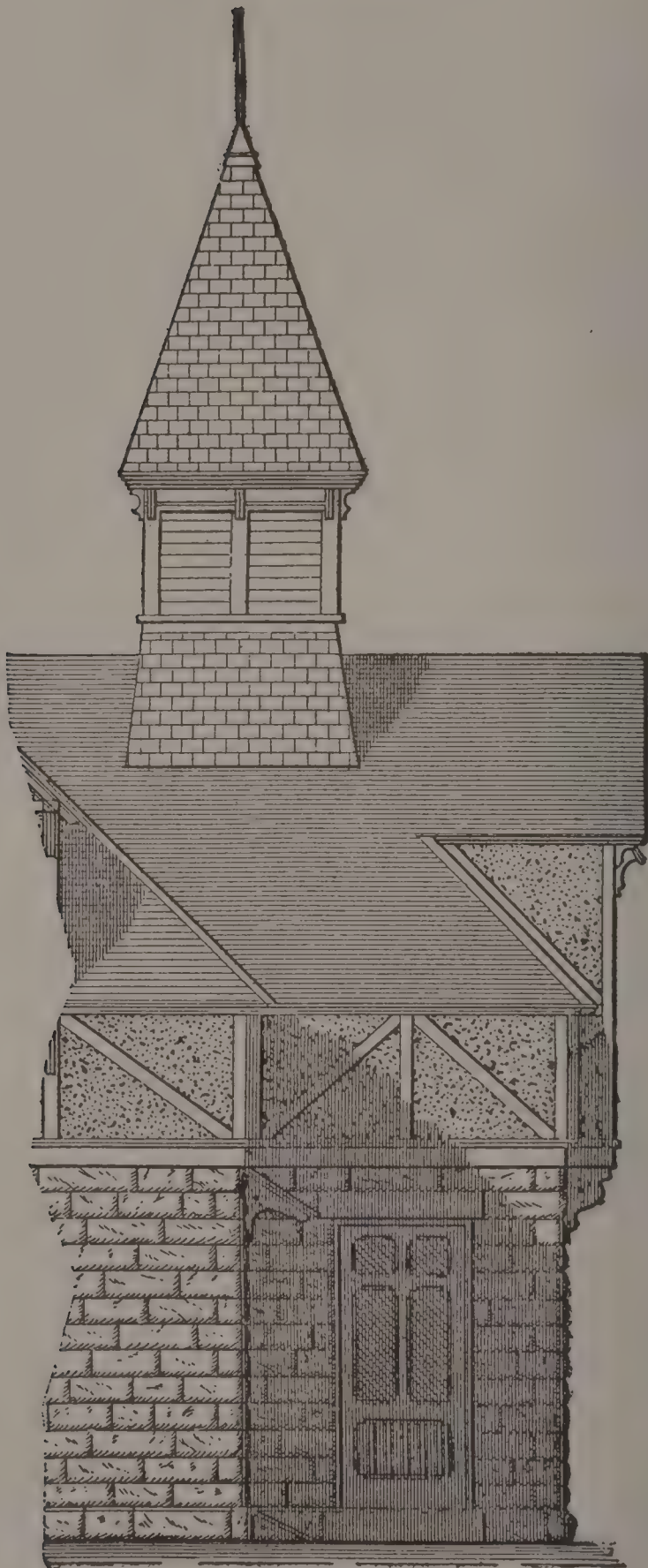


Fig. 183.

that by using studs 2x4 inches as plates and spiking them on top of the joists, as shown in Fig. 185, was all that was necessary to make a good strong job. After plates have been nailed on the joists they are cut plumb down from the outside edge of plate, so that the sheathing may be nailed on. Care must be taken to have the plates true with plan. The studding being erected in the main building, put up the studding in the bay window. There should be two at each angle or a solid piece may be got out to place here. The other studding

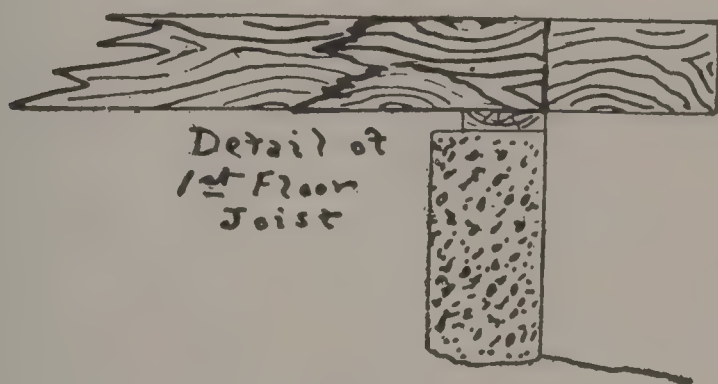


Fig. 184.

should be placed sixteen inches on center. Double plates are used and stay lathed true with templet. The roof plan is shown in Fig. 186. The roof has a raise of one foot above the plate. Rafters are framed and put on as in detail Fig. 186. Then they are cut off on plumb eleven inches from sheathing. Lookouts are nailed on rafters and toenailed in sheathing, care being taken to have them all the same distance from the top of plate and

true. The material for lookouts may be 1x6 inches framed as in Fig. 187. The planceer board is fitted and nailed on lookouts, facia boards fitted

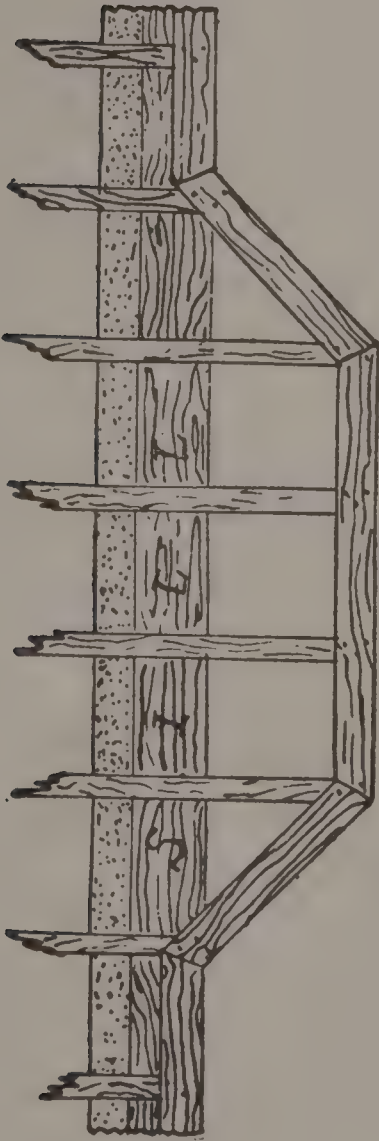


Fig. 185.

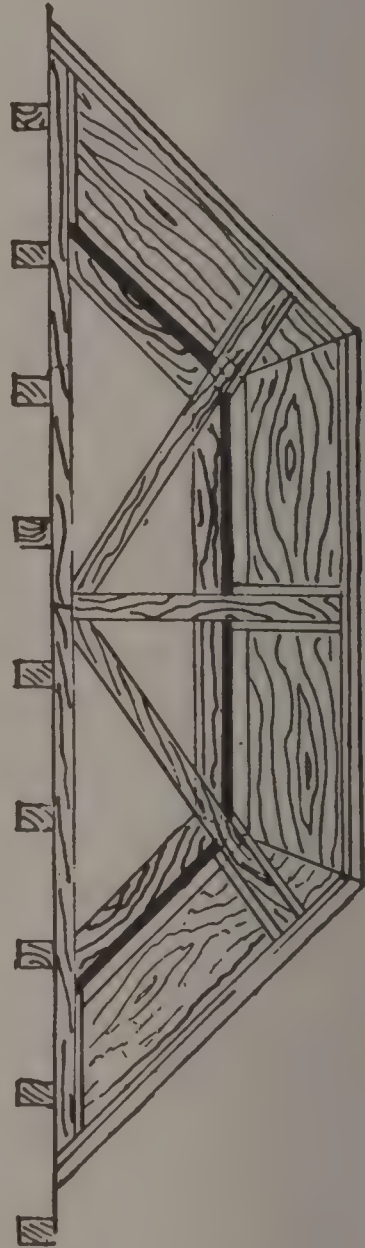


Fig. 186.

and put on, also crown moulding, the top of which should be even with top of roof boards. Shingles being used the hips should be flashed with galvanized iron, also flashing put on against sheathing

on house. The window is sheathed up and the window frames set true. Then we can put on the water-table. Frieze boards are put on and the bed mould, which finishes between frieze and planceer boards, as in Fig. 187. Sometimes corner boards are used on angles. Of course they make the work easier, but a better looking job can be done by mitering the clapboards on these angles. Often a small strip of inch and one-eighth material is

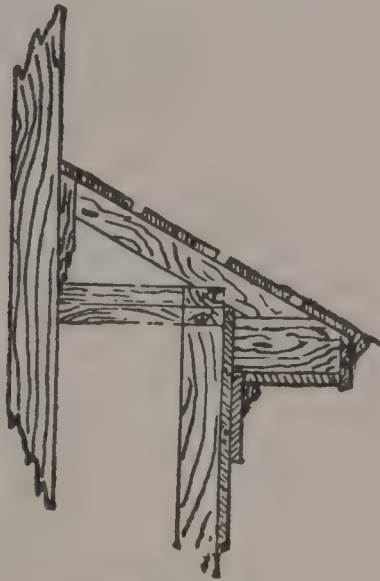


Fig. 187.

fitted to use in the angles against main building. This gives good results as the main part or bay can be clapboarded separately as well. We would advise that a miter-box be made and used to cut clapboards at angles, and if care is taken in laying it out and in the way the siding is put on it to expedite the work. A story-rod should be used to lay off for siding. We have often seen many jobs where poor workmanship and slack methods were

used, also on some jobs where three or four more clapboards were used on one side than on the other, illustrating the need of a story-rod. At Fig. 188 is shown the skeleton framework complete ready to receive whatever covering may be decided upon. The window frames will, of course, be made to fill the openings and should be put in place after the frame is rough boarded and papered. Good paper should be well wrapped around the window studs in order to exclude wind, and if the work is properly done, the whole can be made as warm and as airtight as any other part of the house.

In many localities long scantlings are hard to get and are very costly. To overcome this, 2x4 inch scantlings may be spliced by putting the ends together and nailing pieces of inch stuff on each side of the joint from 18 to 24 inches long and this will make a strong splice for studs that stand on end. Of course, if the stud happens to be for a corner or for a door, or a window jamb, the splicing piece must not show inside the opening as it would interfere with the window or door frame. Sometimes studs are lengthened by allowing them to lap over each other and the lap spiked together with four inch spikes or nails. This is not a good method and should only be made one use of in certain conditions when little or no weight is to rest on the studs. A stout piece of scantling of the same section as the studding, may be nailed or spiked along

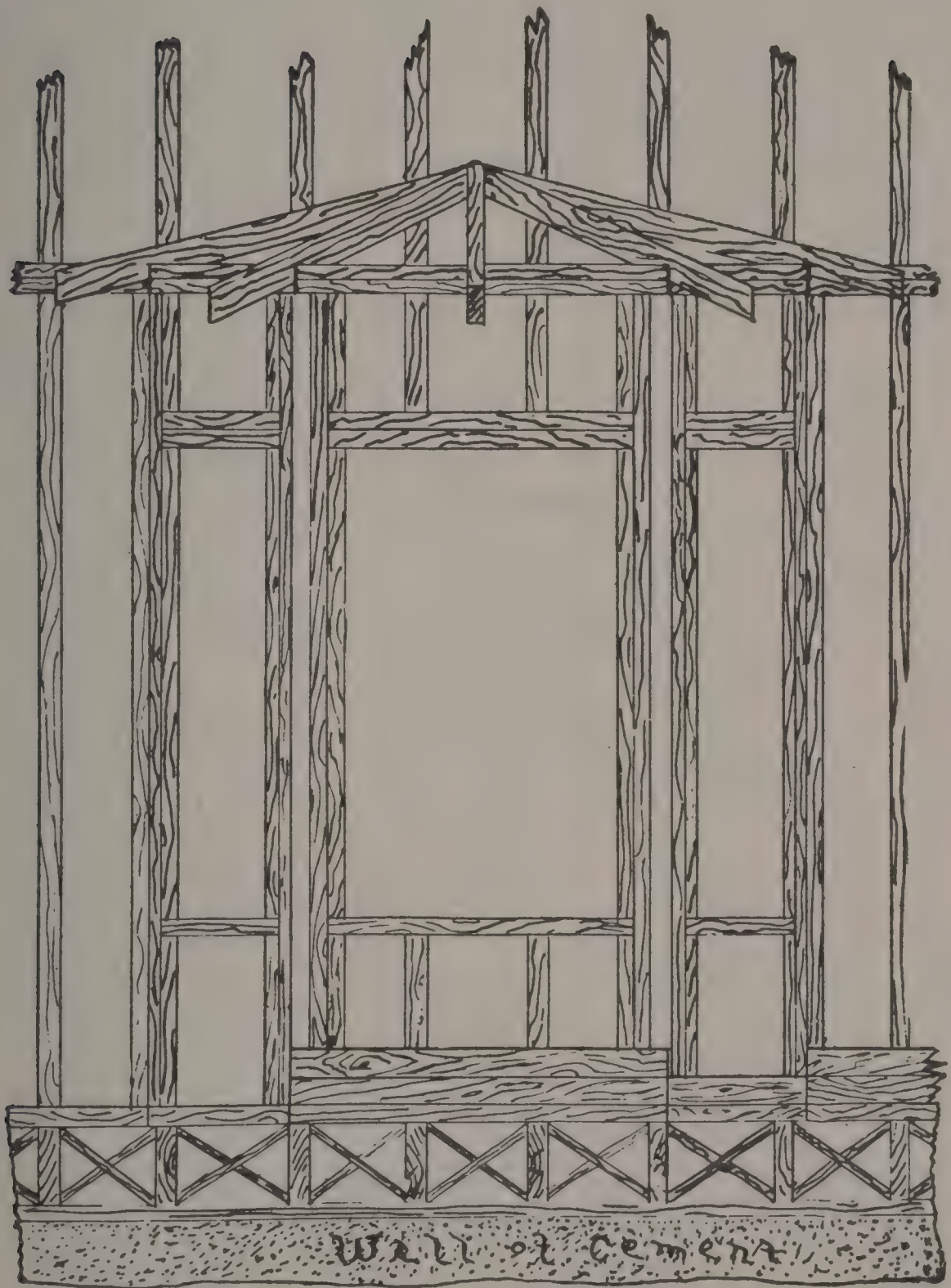


Fig. 188.

the end joints, making a splice that does its work very well.

In putting up a balloon frame with short studs it is usual to put it up in single stories. The first story should be completed as far as the framing is concerned and a rough floor laid for the second

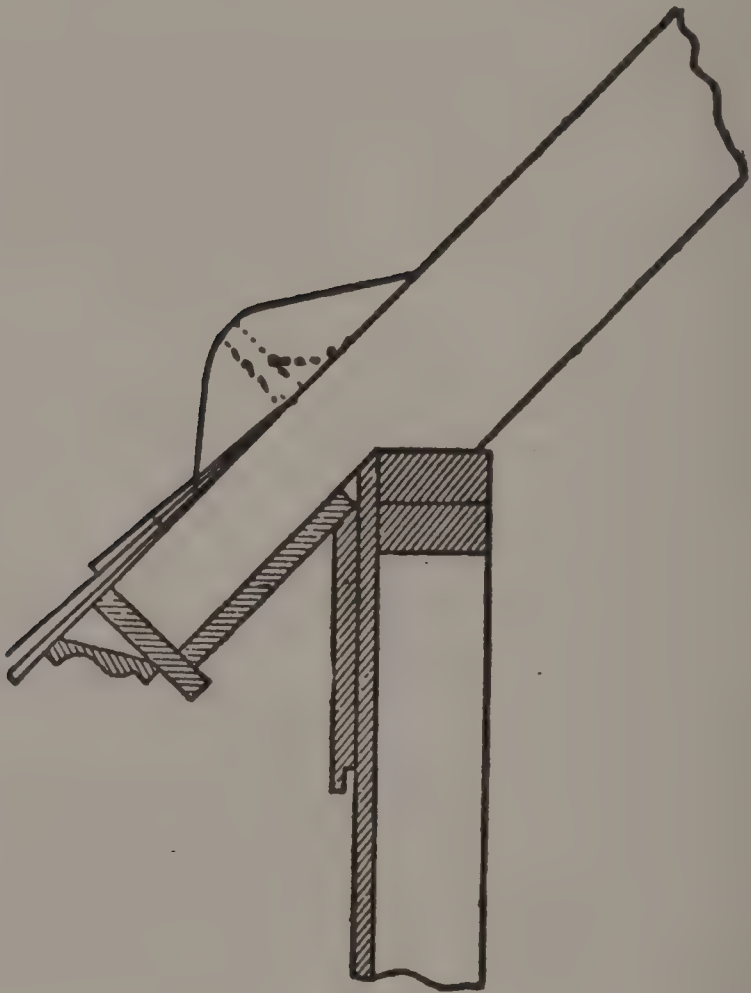


Fig. 189.

story, on this floor 2x4 inch stringers should be laid all around the building on a line with the outside walls and the window and other openings should be marked off on these stringers, and where possible this upper studding should stand direct over

the studding in the lower story; and if this occurs between the joists of the second floor short pieces of studding should be "cut" in between the plate of the first story and the stringer and nailed in solid, which will throw the weight of the upper studding onto the lower studs. Buildings erected this way are strong enough to resist all ordinary wind pressures, but in all cases it is best to

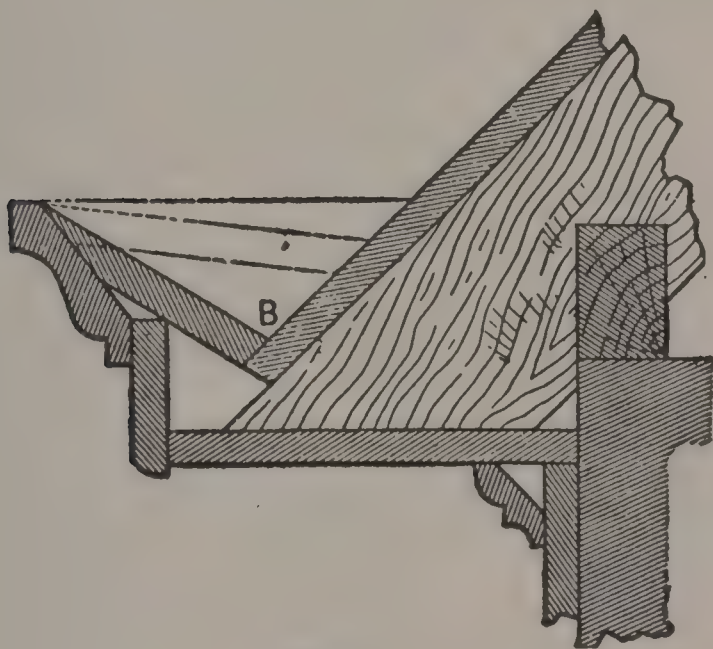


Fig. 190.

board up the outside of the frames diagonally. This insures the tying of the stories together, making the whole building very much stronger and rendering it so that the wind would have to be strong enough to blow over the whole building before the upper portion would budge.

Before leaving balloon or light framing, it will not be amiss to show a few examples of eave or cornice framing suitable to both light or heavy

timber work. Fourteen examples are exhibited from Figs. 189 to 203 inclusive. Fig. 189 shows a very plain cornice with the rafter cut so as to partly rest on the plate, with a portion running over the plate to form the projection and eave. The method of finishing is also shown. Fig. 190 exhibits a somewhat more elaborate cornice with gutter trough at B. In this case the planceer stands out at right angles from the wall.

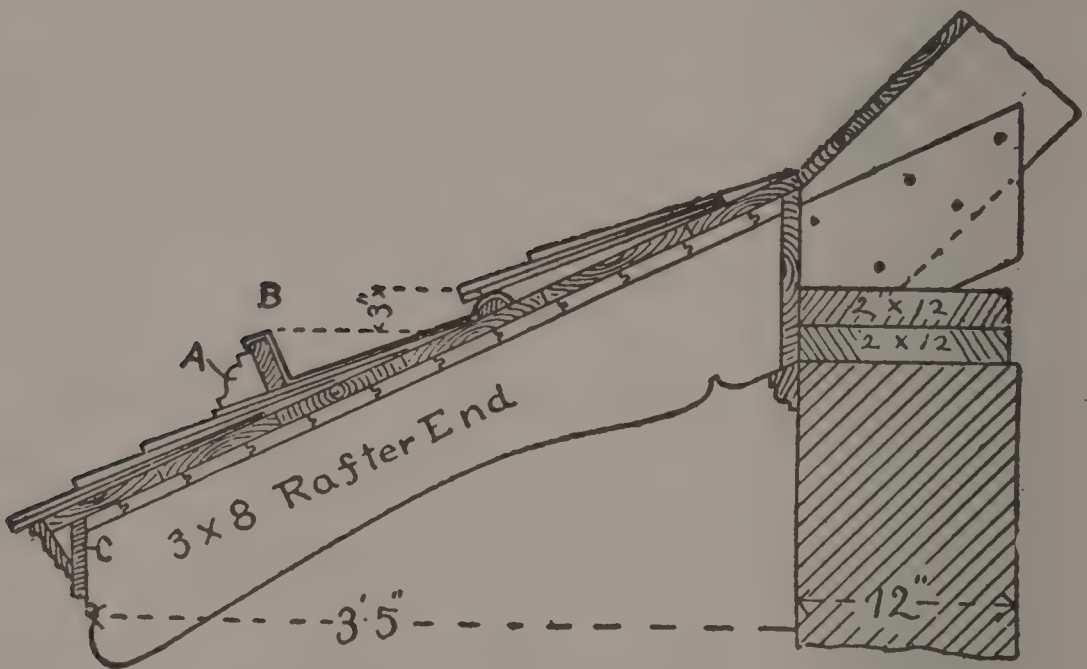


Fig. 191.

Fig. 191 shows a rafter projecting out and over the wall about three and a half feet and dressed and moulded. It will be seen that the projection is of different pitch to the main roof, and this necessitates the projecting and being a separate piece with the inside end spiked to the main rafter as shown.

Fig. 192 shows a cornice where the projecting ends of the ceiling joists play an important part in the construction of the work. The rafter rests on the ceiling joists and is notched over the plate, which may be notched into the joists or spiked in them as shown. The ends of the joists are trimmed off to slope of roof.

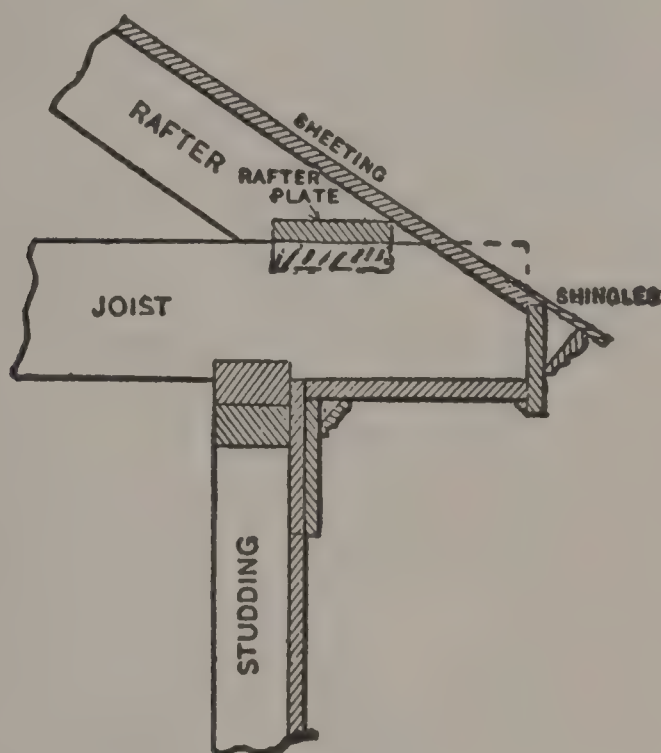


Fig. 192.

Fig. 193 also shows projecting ceiling joists with ends of rafters spiked to joists. This is not good construction but may be used where the roof is not extensive.

Fig. 194 shows an old time cornice with a wooden gutter. This style is seldom used now-a-days, but sometimes people living in the country insist on employing it.

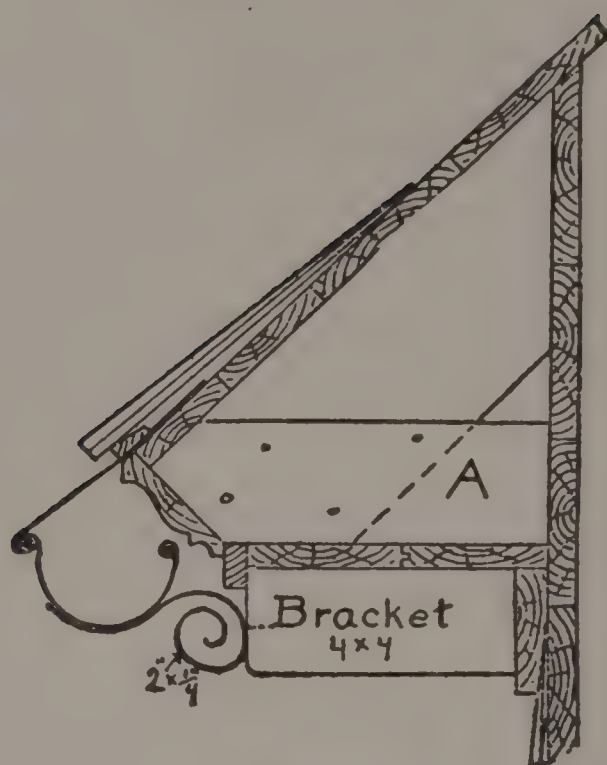


Fig. 193.

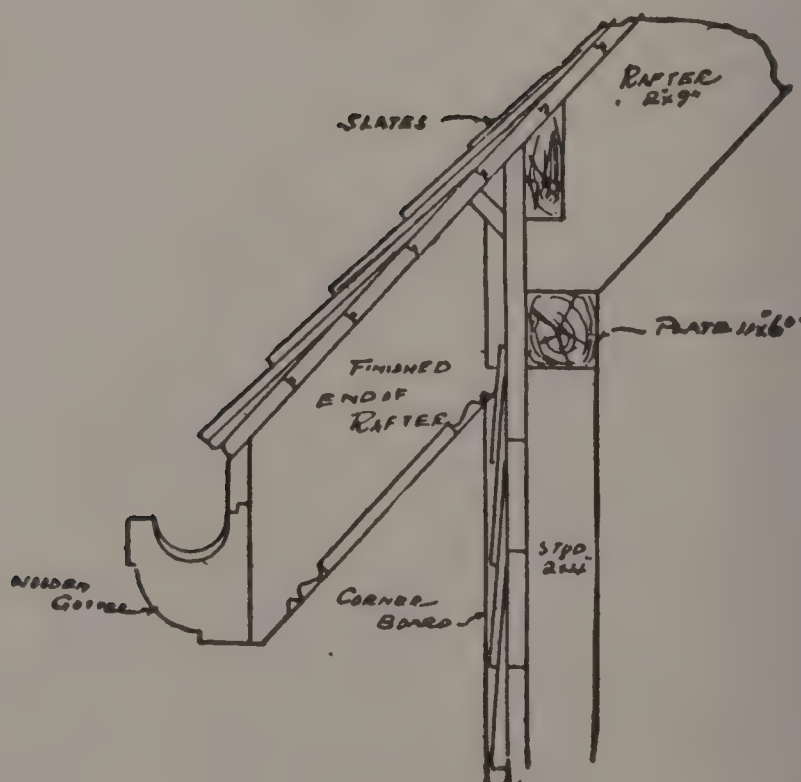


Fig. 194.

Fig. 196 exhibits another cornice on nearly the same lines as Fig. 194. I may say here, that instead of wooden gutters, heavy galvanized sheet iron gutters could be employed to advantage.

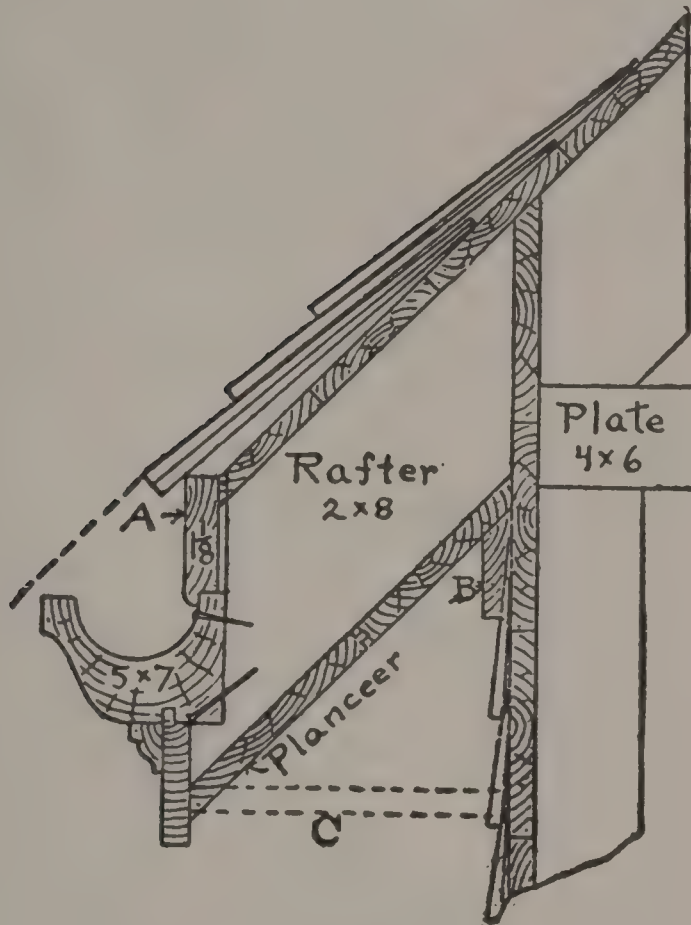


Fig. 196.

Fig. 197 shows a rafter resting in a foot mortise or crow-foot in a solid heavy timber frame. This style of framing rafters is often used in heavy timber work, such as barns, stables, warehouses, freight sheds and similar structures.

Fig. 198 shows another cornice which is intended

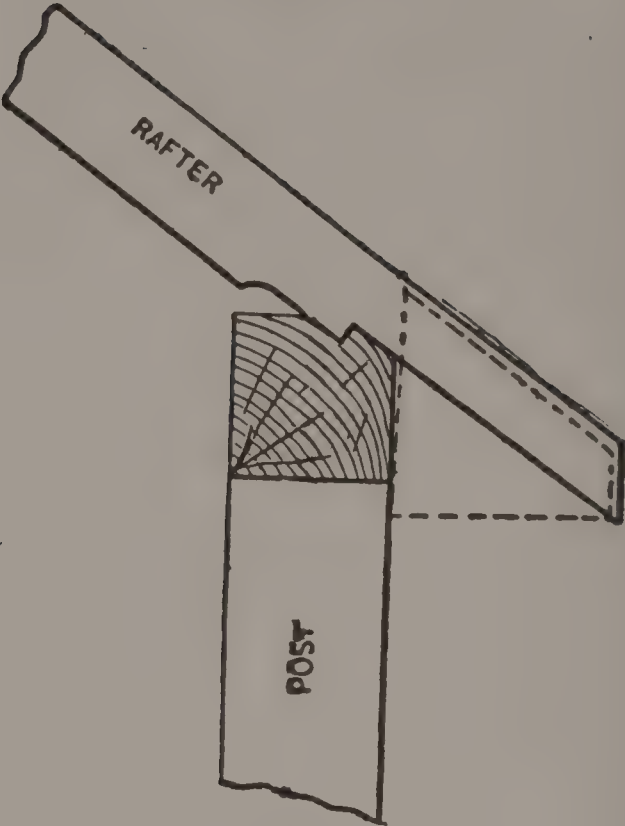


Fig. 197.

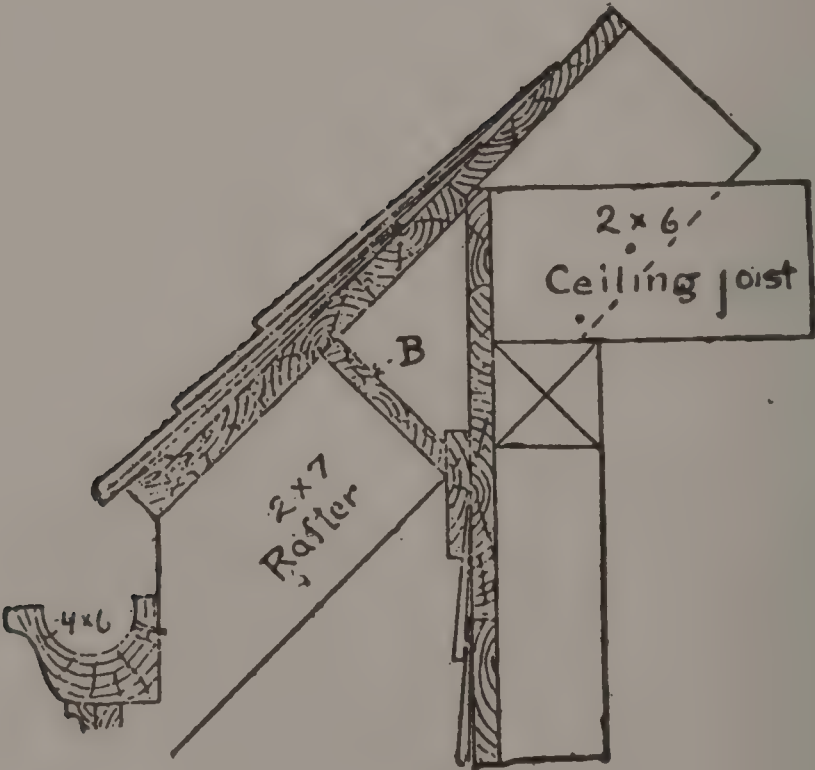


Fig. 198.

to have a wooden gutter. The method of finishing the rafter on the lower end to receive the gutter is shown.

Fig. 199 shows a cornice designed for a brick or stone house having a curve at the eave. The method of finishing is shown and is quite simple,

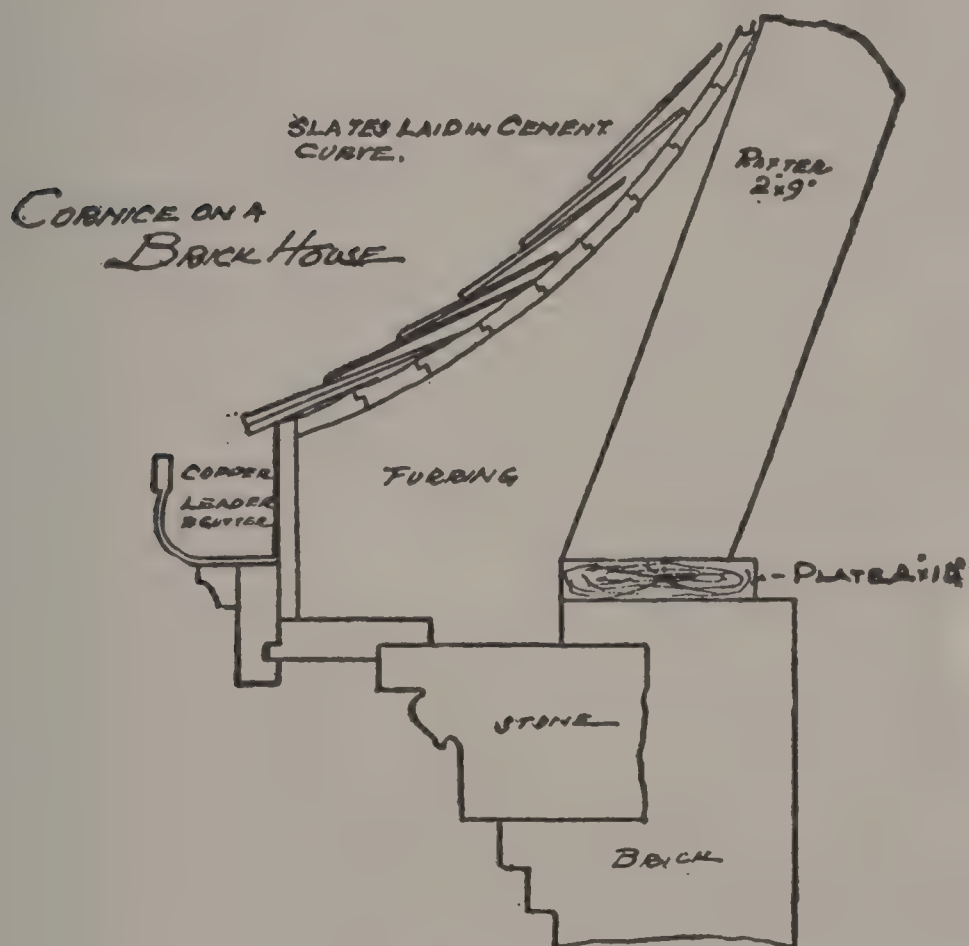


Fig. 199.

the furring being the main thing in forming the curve for the bed of the shingles or slate.

Fig. 200 shows a very good method of forming a cornice for a balloon frame. It is very simple, easily formed and quite effective.

Fig. 201 shows a cornice where the pitch of the roof suddenly changes at the projection, as is sometimes the case with towers, balconies and over bay windows. The method of construction is shown very clearly in the illustration and may readily be followed.

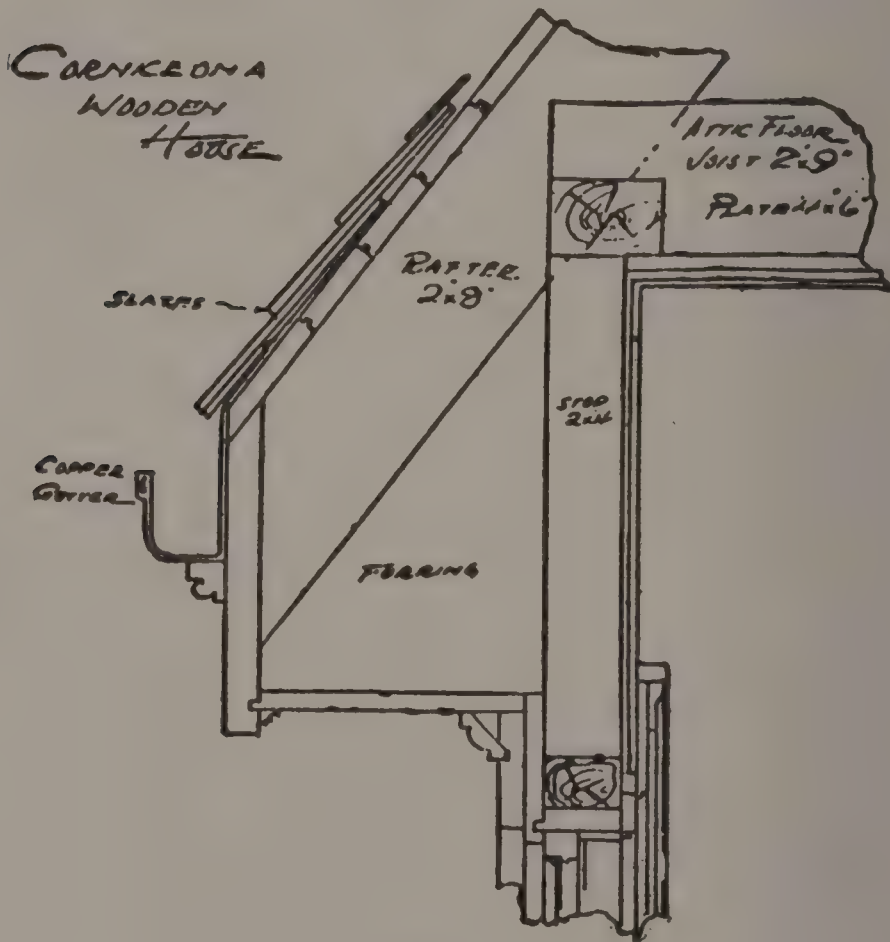


Fig. 200.

Fig. 202 shows an ornamental cornice which may be used either on cottage or veranda work. A portion of the rafters shows as brackets below the planceer.

Fig. 203 shows a part of a veranda roof, with brackets, gutter, and facia. Here the roof has a very low pitch and the rafters are nailed against

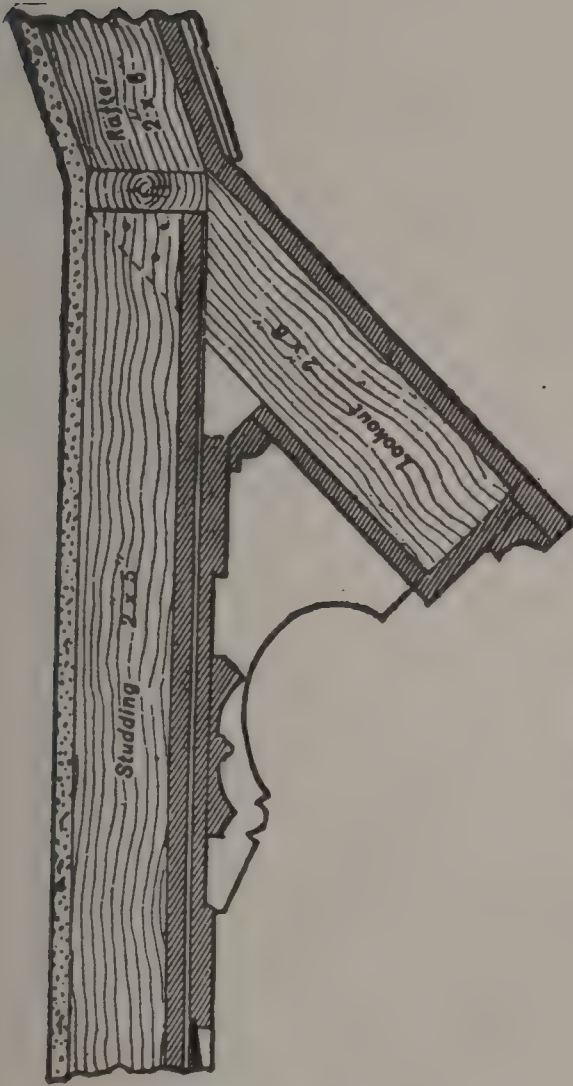


Fig. 201.

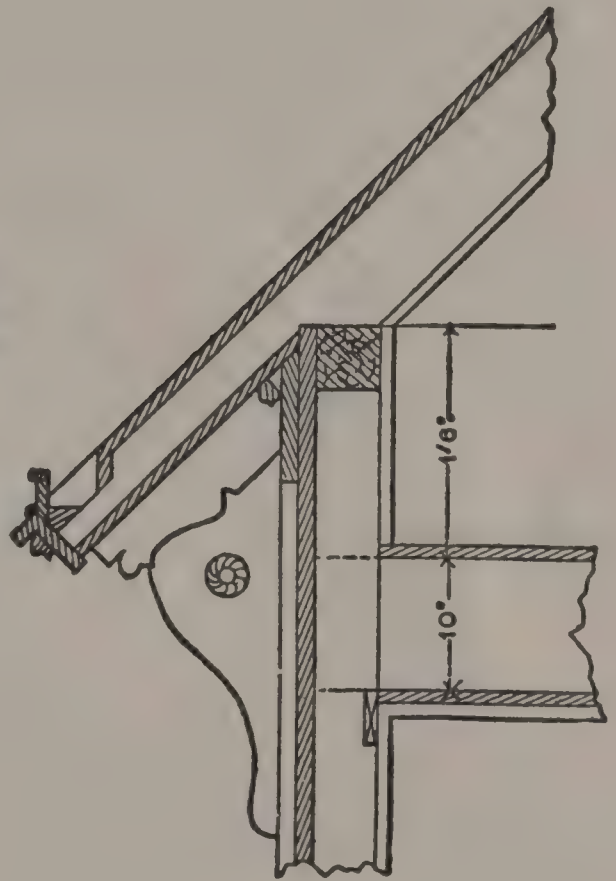


Fig. 202.

the sides of the ceiling joists and the depression for the gutter is cut out at the end of the rafter as shown. The gutter, of course, like all similar gutters, is lined with galvanized iron, zinc or tin.

These examples of cornices are quite sufficient for the framer to have by him; if other designs are

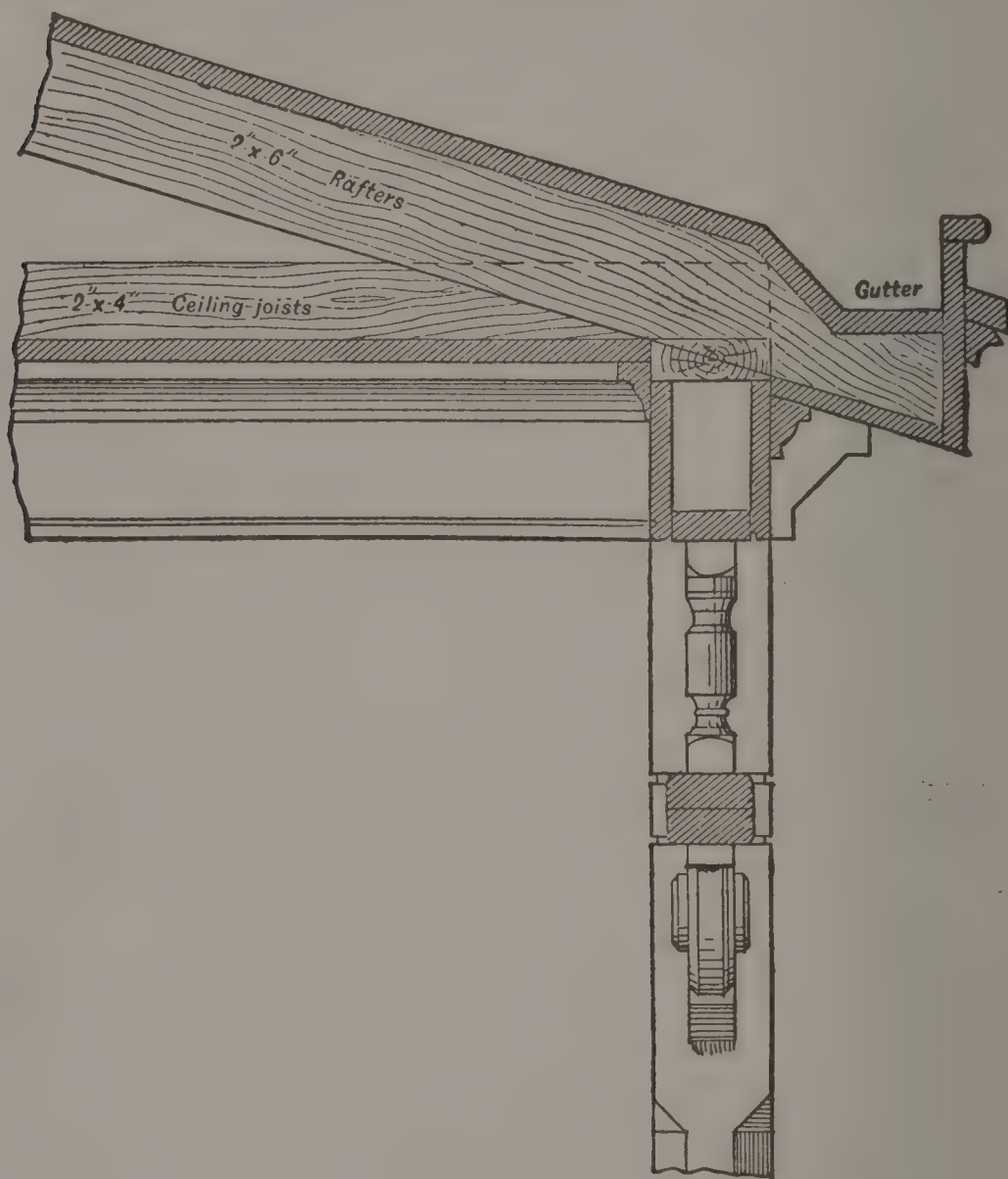


Fig. 203.

required, the workman should experience no difficulty in forming what he wants, having these designs at his command.

INTRODUCTION TO PART II.

“*Heavy Timber Framing*” is an art that requires considerable skill on behalf of the man who “lays out” the work, because of the fact that this work must be carried on without “trying” how the work coincides, or in other words, without being able to make use of the good old-fashioned rule of “cut and fit.” The lengths, cuts, locations and duties of each piece of timber used in the construction of heavy frame work, must be considered by the framer, and each piece entering into the building, must be mortised and wrought separately. This is no easy task, and the person undertaking it assumes no small responsibility and his position is such as should insure to him a remuneration commensurate with the position and responsibility he accepts. Unfortunately, the “boss framer” receives as pay but very little more than the regular carpenter, something that is not as it should be, and if he were not ambitious, and proud of his ability as a framer, he would not accept the position, but rather take a place among the ordinary workmen and thus escape the responsibilities of “Bosship.”

PART II.

HEAVY TIMBER FRAMING.

“Is heavy timber framing a lost art?” This question has been asked me many times during the past twenty years and I have invariably answered it in the negative.

“Heavy timber framing is not a lost art.” If necessity arose tomorrow in the United States or Canada, for the services of five thousand competent framers they would be forthcoming within a period of sixty days if inducements were sufficiently attractive. Since the introduction of steel frames into building construction, the use of timber frames in roofs, buildings, bridges and trestle work has greatly fallen off, particularly in or near large cities, where timber has become scarce and costly, but in the west, north, and south, timber structures are often made use of, and will be for many decades yet. Indeed, even when steel is made use of timber has to be frequently employed in special cases; so that a knowledge of framing is as necessary to the general workman to-day as it ever was. When I say this, I do not mean that it is necessary to become an expert framer, but that a knowledge of the proper way to handle and

lay out timber, should be possessed by every man who aspires to be a competent carpenter.

Heavy framing is an art that requires considerable ability and intelligence on the part of the operator, inasmuch as it is not one of those branches of the trade where the "cut and fit" process can be applied. Each piece of timber, whether it be a girt, a chord or beam, a post, brace, sill, girder, strut or stringer, must be dealt with, and given its proper shape, length and relationship to the part or parts it is to be connected with, without its being brought in direct contact with it until all is ready to be put together and pinned up solid. A clear head and a good memory, along with the faculty of exactness, are absolutely necessary qualifications for the making of a good framer. He must see to it that all tenons are the right size to suit the mortises which they are intended to fill, and that all mortises are clearly and smoothly finished and not too large or too small to snugly receive the tenons, and all this must be done without any "trying and fitting." The charm of good framing lies in the fact that every mortise and tenon must be "driven home" with a heavy wooden mallet; but tenons should not fit so tight as to require more than ordinary driving.

The tools required by the heavy timber framer are not numerous, but are heavy and somewhat

costly. I give a list of most of the tools employed herewith:

An ordinary chopping axe.

A good heavy headed adze.

A heavy 8 or 10 inch blade broad-axe.

A carpenter's 4 or 5 inch hatchet.

A ten foot pole made of hardwood.

A steel square, ordinary size.

A bridge builder's square with 3 inch blade.

Two or three good scratch awls.

Chalk lines, spools and chalks.

Several carpenter's heavy lead pencils.

One or two pairs of "winding sticks" or battons.

One "slick" or slice with 3½ or 4 inch blade.

A good jack plane and a smoothing plane.

A boring machine with four augers.

Three or four assorted augers for draw-boring

An ordinary sized steel crow-bar.

An adjustable cant-hook, medium size.

A couple of good hickory or ironwood hand-spikes.

A half dozen 4 inch maple rollers.

Four good framing chisels, 2 in., 1½ in., 1¼ in., and 1 in.

A two-hand cross-cut saw about 5 feet long.

A good hand-saw, also a good rip-saw.

Two oil stones, and a good water-of-Ayr-stone.

Sometimes a medium weight logging chain will be found very useful.

An adjustable bevel will come in handy at times.

These, with a few other tools that will suggest themselves from time to time as the work progresses, will be all that will be necessary to frame the most complicated frame structure.

While I do not intend to give a lengthy description of these tools or give prosy directions regarding their use, care and management, I deem it proper to say a few words on the subject: The common chopping or woodman axe is so well known

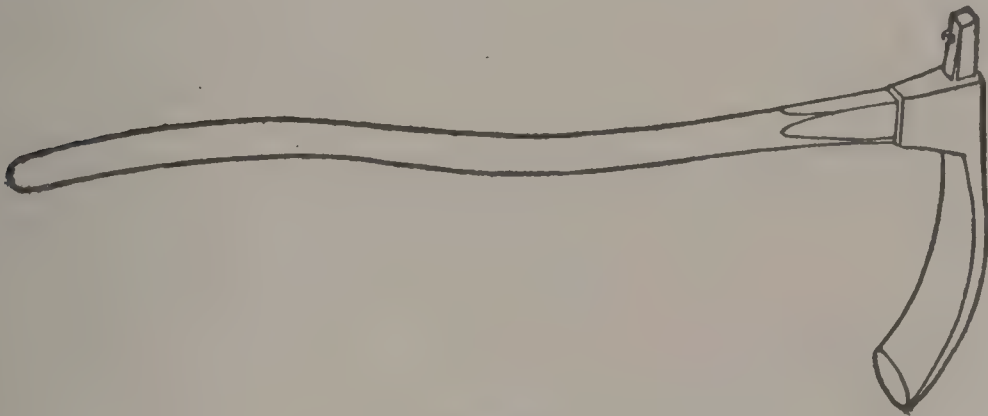


Fig. 204.

to every American that I need not say much of it at this juncture. It is one of the most useful tools the framer possesses, as it can be used for so many purposes; indeed, in the hands of some workmen it can be made to take the place of several tools. It is sharpened from both faces.

The next in order will be the adze, which should have a good heavy steel faced pole or head. This should have a well tempered cutting blade not less than three inches wide, and should have a handle shaped as shown in Fig. 204. This is a dangerous tool for the inexperienced workman to use, and

differs from the axe, as the cutting edge is at right angles with the handle. It has been named "The Devil's shin hoe," as it has made many a serious wound in workmen's shins. It is ground from one



Fig. 205.

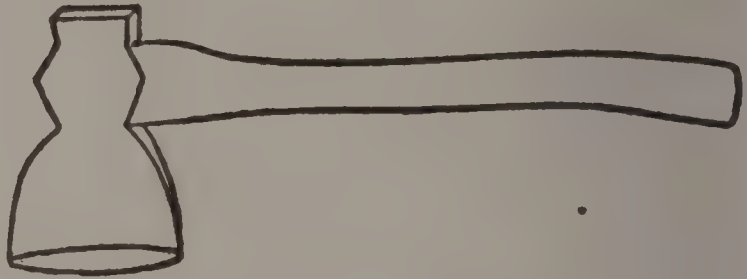


Fig. 206.

face only. At Fig. 205 I show the style of chisel that should be used in framing. These can be obtained in any sizes from half inch to three

inches. They are heavy and strong and with care will last a lifetime.

The hatchet shown at Fig. 206 is a very handy tool for the framer, and may be used for many purposes, more particularly for making pins or pegs to fit the draw-bores. It is also useful for splitting off the surplus wood from the shoulders of the tenons.

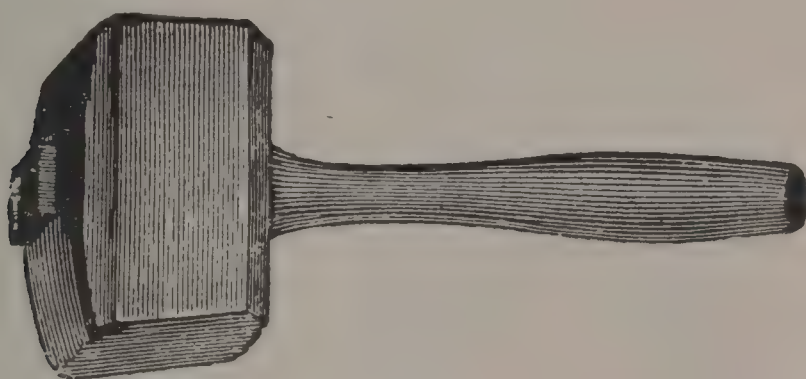


Fig. 207.

The mallet shown at Fig. 207 is a common type and is used for beating mortises or hammering the chisels. These mallets are made in several forms, some with square heads like the one shown, or with round heads, Fig. 207 $\frac{1}{2}$, having flat faces, and are often protected on their working faces by leather, and having iron hoops driven on them to protect the working faces from splintering or battering when being used on the chisel.

The boring machine, shown at Fig. 208, is used for relieving the mortises of their cores and making them easier to “beat” out with the chisel and

mallet. This machine can be adjusted for angle boring as well as vertical. A loose auger is also shown. Generally four augers of various sizes are sold with each machine.

Hand saws will be found very useful, the cross-cut, as shown at Fig. 209, for cutting the shoulders, and the rip-saw for cutting the tenons, and uses for both will be found in much other work about a frame building besides shoulders and tenons.



Fig. 207½.

The long cross-cut saw is an indispensable tool to the framer (Fig. 210) for cutting off timber, cutting shoulders and other work. It is scarcely necessary to show illustrations of the other tools required by the framer, as we may have occasion to refer and illustrate them later on.

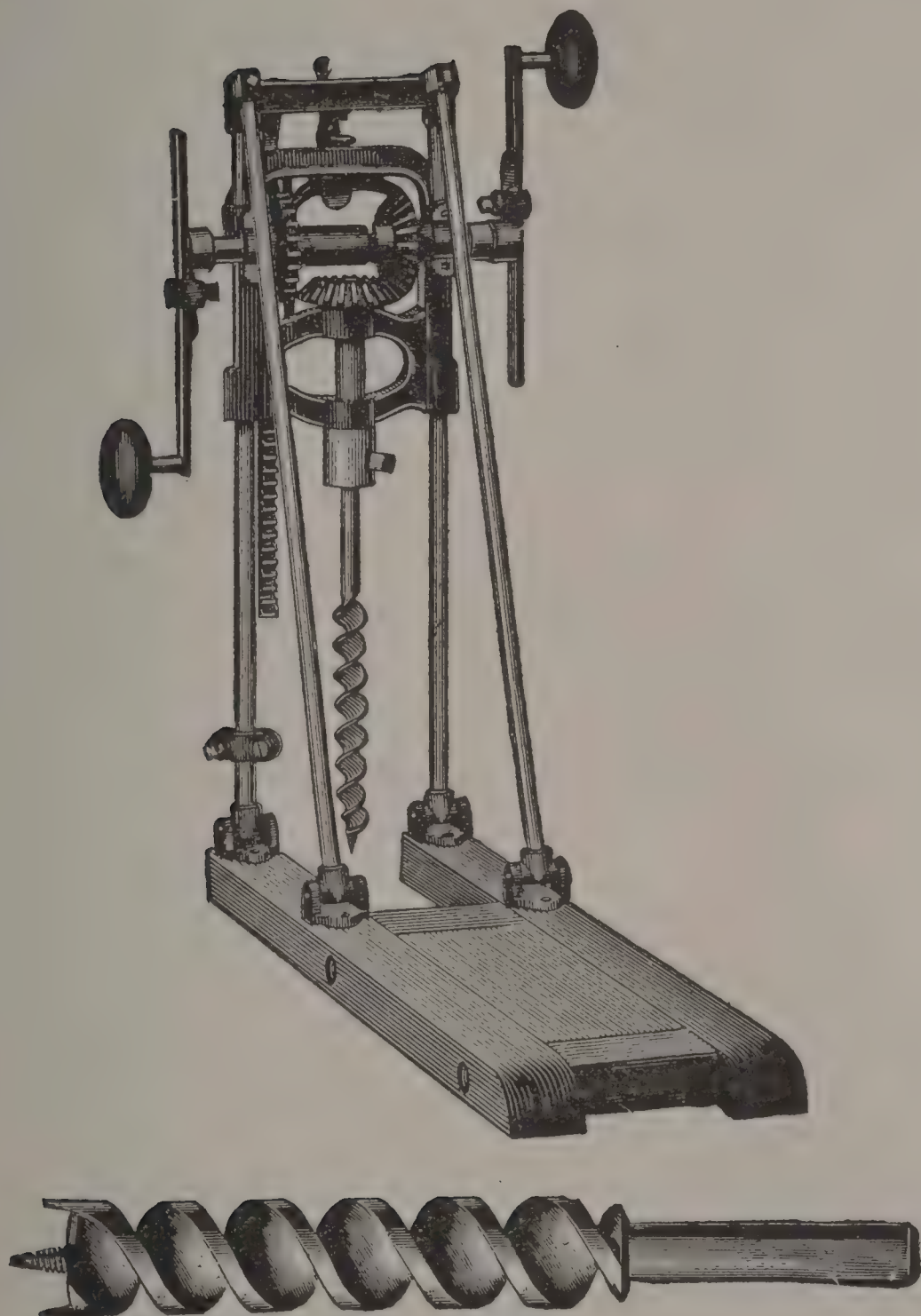


Fig. 208.

Thirty years ago it was the custom in most of the States where there was standing timber for the framer to go into the woods, choose the timber for his work, fell it, rough hew it, and finally have it hauled to the location, by oxen or horses,

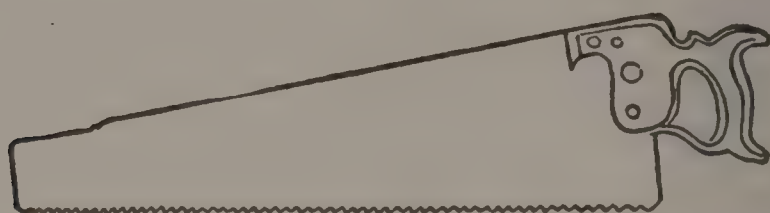


Fig. 209.

to where the barn, house, or bridge was to be erected. This practice, I am informed, is still continued in Maine and several of the Western States, but owing to the fact that saw-mills are so numerous in wooded districts, capable of cut-

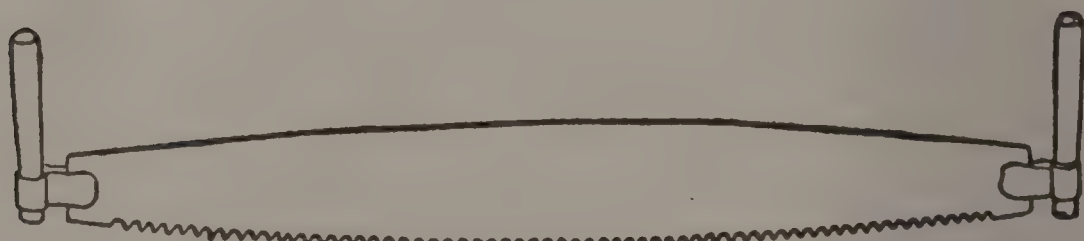


Fig. 210.

ting timber to any reasonable length, the practice of hewing has fallen almost into disuse; and because of this fact I deem it inexpedient to show and describe the various methods of manufacturing square timber from the round.

It is often necessary to mortise and tenon round logs for rough work, and to enable the young workman to accomplish this I show, at Fig. 211, a simple method of finding the lines for this kind of work. The illustration shows a round stick of timber, with chalk lines oo and RR struck on two sides of it. These lines are first laid out on the pattern x, as shown, from which they are transferred to some point on the timber, as nearly the center of its cross section as possible at each end of the stick and as plumb from the center as can be obtained. The pattern x which is formed of

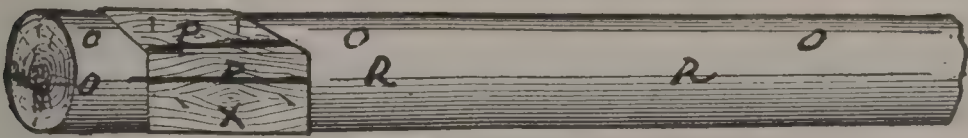


Fig. 211.

two boards—any reasonable length—nailed together exactly at right angles to each other, with the ends cut off square, must then have a line drawn on both its faces, as shown at P P. The pattern is then laid on the timber, the top line being made to correspond with the lower line on the pattern. From this lower line, the second chalk line on the side of the timber should be struck. The end of the pattern forms a square, and if the timber is cut off on the lines of the end of the pattern, that end will be at right angles with the axis of the timber.

Mortises and tenons may be laid off from the chalk lines by measurements as may readily be seen. Lines drawn across the mortises by aid of the pattern will be at right angles to their sides; the tenons may be laid off in the same manner, and by correct measurement made so as to fit into the mortises snug and tight. If it is desirable to "draw-bore" this work, it may be done by a proper use of the pattern by pinking a hole through it where the draw pin is to pass through the mortise and tenon. If a square bearing is required for the shoulders at the tenons, it may be readily done by squaring across the mortise, using the pattern for the purpose.

This, perhaps, is all the information on the subject of round timbers the ordinary workman will ever require, but should he require more he should have no trouble in getting through with his work, as the foregoing contains the whole principle of working round timber. First, the board pattern as described, then line up the timber with straight chalk lines, and the whole system is opened up, so that any wideawake workman can manage the rest.

In working square timber, it is always necessary to have all points of junction square and "out of wind," or out of "twist" as some workmen call it. To take timber out of wind is quite a simple process—when you know how—and to "know how" is a matter only of a few moments' thought

and experience. The tools required to do this depend very much on the amount of “wind” or “twist” the timber may have. If a large quantity has to be taken off, as shown at Fig. 212, it will require an ordinary chopping axe and a broad axe;

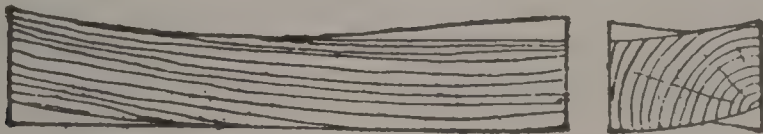


Fig. 212.

the first to lightly score or chip, and the last to finish the work smoothly. Sometimes a jack plane is used to finish the timber nicely when good clean work is required. The winding sticks or “batts” are placed on the timber as shown at Fig. 213,

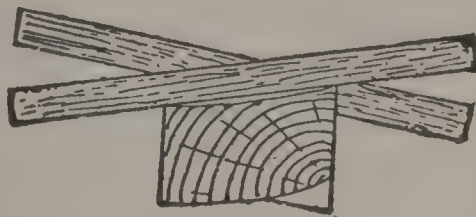


Fig. 213.

which gives an idea of the amount of wood that must be removed before the timber will have a fair plane surface. The manner of using the “batts” or winding sticks is shown at Fig. 214, where by sighting across the tops of the sticks the amount of winding can be easily detected.

The winding “batts,” which are parallel in width, are placed across the wood (see Fig. 213),

and has the effect of multiplying the error to the length of the sticks. For this reason it is as well to make the sticks 1 ft. 6 in. to 1 ft. 8 in. long. To insure accuracy in long pieces of wood, the winding "batts" should be moved to two or three different positions down the length of the wood and the straight-edge used lengthwise.

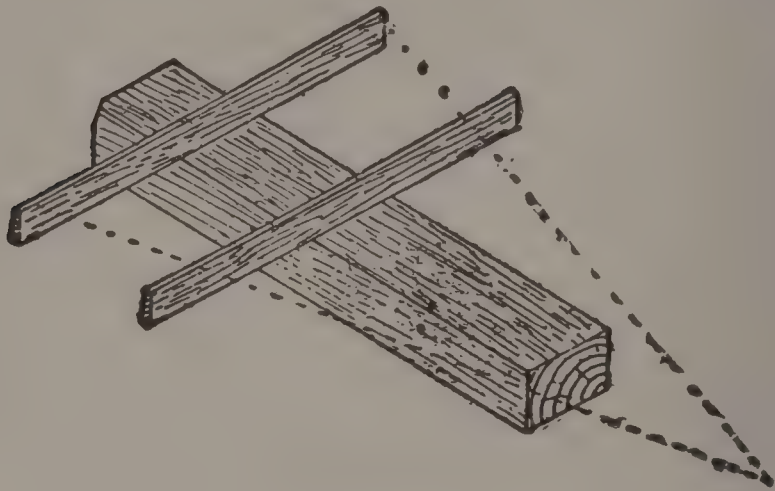


Fig. 214.

It is not necessary to use the winding "batts" on either of the other surfaces of the wood, as the face edge is made at right angles to the face side, bringing into use the try-square and straight-edge. The other two surfaces are planed true to the gauge lines, which are put on parallel to the first two surfaces. The writer has two of these winding "laths" which he made for himself over fifty years ago; they were made for bridge work and are made of black cherry, and are as true to-day as when they were first made.

In preparing timber for framing, it is not necessary that the whole timber be made to line, as this often entails a great deal of extra labor. The timber may be "spotted" or "plumbed" or "squared" at the points where girts, braces, studs or other timbers join the main timber. The object of this is to make a proper surface for the shoulders of tenons to sit against. This, however, may be very much assisted by adopting the following rules and making winding "batts" to suit the work.

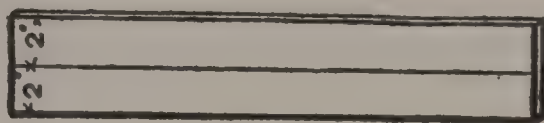


Fig. 215.

The method, in full, may be described as follows: Referring to the illustrations, Fig. 215, shows what is called the wind batt. In taking the wind out of a timber, two wind batts are required. This wind batt consists of a piece of board $\frac{1}{2}$ by 4 in. and about 18 in. long. The edges of the batt must be made parallel to each other. Then a line is drawn down the center, leaving 2 inches on each side of the line, as shown in the sketch. The bradawl is then stuck through the bottom half for the purpose of fastening to the end of the timber. The wind batts are then stuck on the ends of the piece of timber as shown in Fig. 217 of the sketches, half the batt projecting above the timber. The

operator then sights over the upper edges of the batts and moves either end until the edges coincide. He then takes the scratch awl and marks across the bottom edge of the batts at each end of the timber, as shown in Fig. 218. This completes one side. The rest is easy, as in the other side the

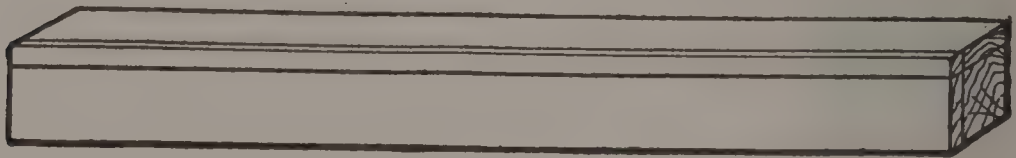


Fig. 216.

wind is taken out by means of a steel square, as indicated in Fig. 217. Place the inside edge of the tongue of the square even with the line made by the wind batt, the outside edge of the blade being even with the smallest place on the outside of the

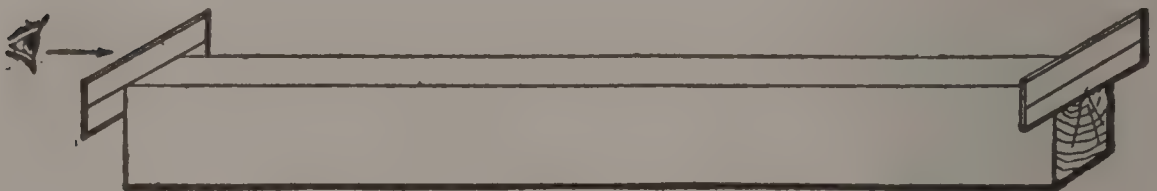


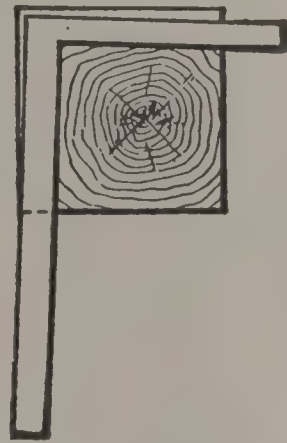
Fig. 217.

timber. Mark with a scratch awl down inside of the blade. Move the square up 2 inches on the timber and mark through to the top of the timber. The latter is then out of wind and the operator will proceed to line it, as shown in Fig. 216, which represents a stick of timber with the wind taken

out and lined. Stick the scratch awl in the end of the timber at the point where the plumb lines cross each other, the awl being through the small loop in the line. All four sides of the timber may be lined without moving the scratch awl. In taking the wind out of timber in this manner considerable time is saved, as one man can take it out of wind and line it without other help.



Fig. 218..



g. 219.

From another source (*Carpentry and Building*) I get the following directions for preparing timber for framing from the pen of a practical framer who seems to know pretty well of what he is talking and starts off by saying: "The first step in the process is to scaffold your timber so that it will lie straight and as nearly level as possible, and so that you and your men who follow may work over it in a comfortable position. That done, suppose, as in Fig. 220, we have a corner post to lay out which is $8\frac{1}{2}$ by $8\frac{1}{2}$ by 16 feet, and from

shoulder to shoulder of tenons is 15 feet. I would select the two best faces that give nearest a straight corner, taking a corner that is hollow rather than one that is full. Then I set one square on across the best face, far enough from the end for a tenon, and measure 15 feet towards the other end, making an irregular mark across the face at this point with a heavy pencil as I did at the other end. I then set my second square on this mark and look over the squares. Just here comes in the nice point in unwinding timber. If at the first glance over the squares they should be very much in wind, then adjust the difference at each end by

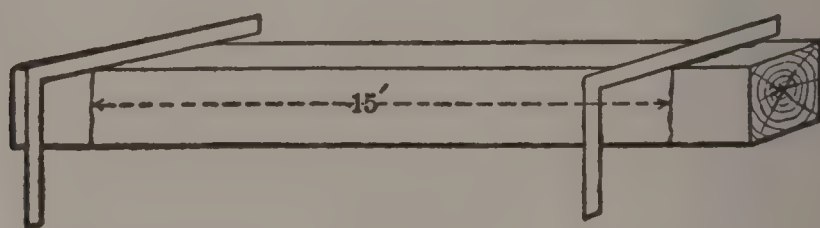


Fig. 220.

dividing. But this rule does not always work, for the wind may all be in the last two or three feet of the stick—more likely than not at the butt end. You will soon learn by looking over the faces of the timber to locate the cause or place of the wind. You will soon learn also that it requires but a slight change to adjust the squares so that there may be little cutting necessary in making the plumb spot. But to go on: With your adze or chisel (I mostly used a 3-inch slick) level off

across the face of the timber as much as you think will be necessary to bring the lines right in the end. While at this end of the timber spot the side face, then go to the other end and unwind with the spot already completed. After making the plumb spot on the side face take your scratch awl and point with 2-in. face each way from your plumb spot, going around the four faces of the timber. Line through these points and work from the lines in laying out.

Suppose we have a cap sill to frame, full length, say 10 by 10 by 46 feet long and with the same bearings, bays each 14 feet and the floor 18 feet wide, all as represented by Fig. 221; I start at one end and measure through, making at the principal points (14 plus 18 plus 14 feet) with irregular pencil lines, selecting, of course, the best face for the outside. Then I test the timber through from end to end, looking over the squares before starting to unwind. If the squares line up well at first glance, then I go to work at one end and unwind through. If not then I try through at the other points. After deciding how and where to start, the process is similar to that of the post, and in like manner would I go about unwinding all the timbers of a frame.

From what I have just said you will observe that my rule for spotting timber was, at the shoulders of posts and at principal bearing of long timbers. Following this rule you will have true

points where the most particular framing is to be done.

Sometimes, however, when I come to the short posts in the under frame, where several would

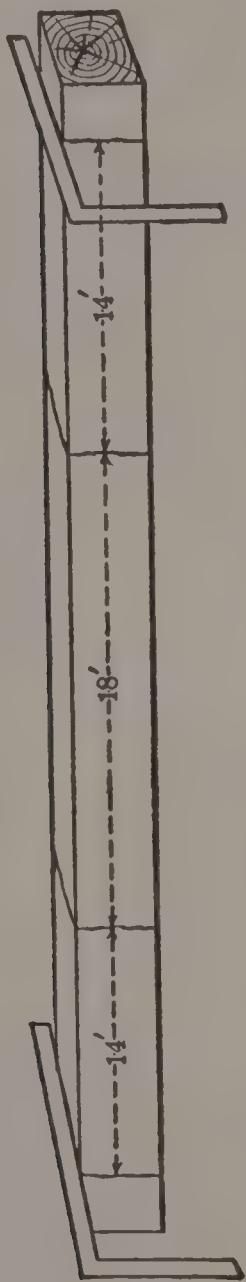


Fig. 221.

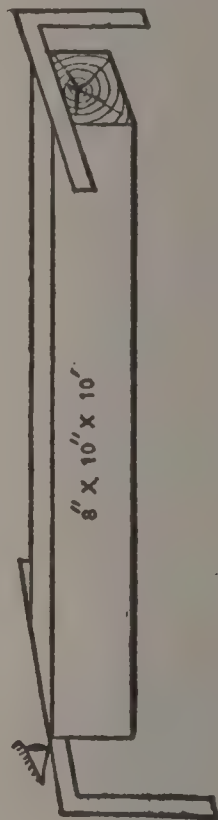


Fig. 222.

be of the same length, including tenons, and a man at each end with square and pencil, as in Fig. 222, would unwind them, marking along the square

across the end of post, allowing 2 in. for face. Square from this line on the same hand at each end with 2-inch face. Lining from these points we have the posts ready for laying out, as shown in Fig. 223.

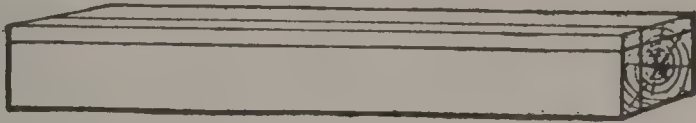


Fig. 223.

Some framers think that time is saved by this method, but I doubt it, for usually there is one side extra at each tenon to size, and I am inclined to advise that spotting in the manner first explained is the better way.

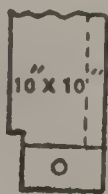


Fig. 224.



Fig. 225.

The two figures here given explain what I have just said about the extra sizing. Fig. 224 is the end of a post framed, where the plumb spot was made at the shoulder. Fig. 225 that of a post where the wind was taken out by the last process described, in which case, unless the timber was exceptionally well dressed, there was overwood and sizing as shown.

In ordinary framing it was not necessary to cut the plumb spot fully across the face of the timber—just far enough for the bearing to steady the square—2 or 3 inches. If, however, you are required to do a very nice job of framing, and are paid for doing it, then cut your plumb spot fully across the face of the timber and choose the full instead of the hollow side for face. Line the overwood on both corners and counter hew. If the timber requires two faces, as for a post or wall plate, then turn the new face up, line and counter hew the other side. That done, mark your points, and line for laying out.

What do I use for lining? Chalk is good, but chalk washes off, and in the showery spring time, the barn builder's season, I generally used Venetian red and water in an old tin, the "boss" holding the tin and line reel with a crotched stick over the line, while one of the "boys" carried the line to the other end of the timber as it paid out. Under favorable circumstances, with one wetting, I was able to line the timber around on all sides.

There is one point worthy of notice, and in favor of the method of locating the plumb spot as given above: It serves as a check against mistakes in measurements. The process of laying out, as practiced by myself, was to unwind the timber as I have shown. Then starting at one end, scribe the extreme point and lay off the

work there and work back again on the intermediate work. Coming out right was almost proof that the work was correct, for, as you will readily see, the timber had then been measured three times."

These are excellent directions and are equally applicable to sawn as to hewn timbers. The workman will, now, I trust, be fully able to understand the importance of taking his timber out of wind, and the proper way to do it.

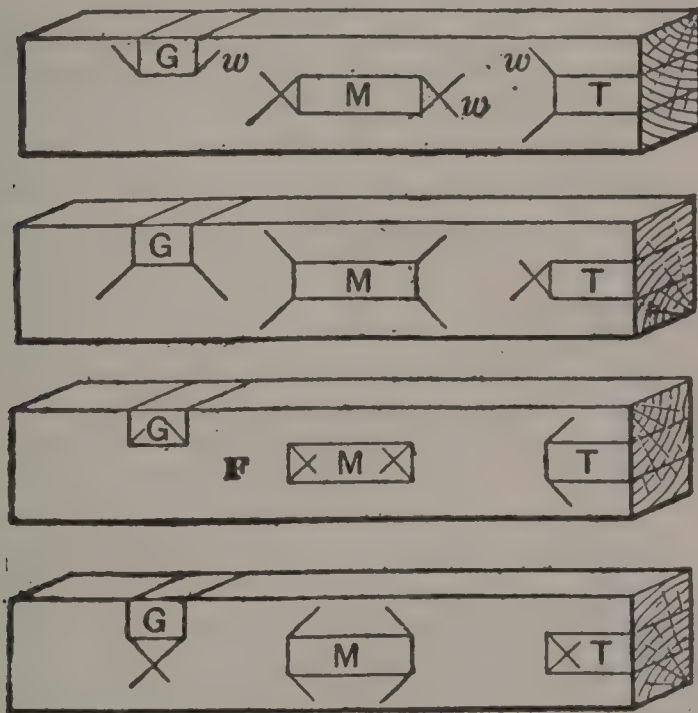


Fig. 226.

The next thing to be considered are as what are known as "witness marks." These marks are intended to inform the men who beat out the mortises, saw the tenons and clean up the gains, and finish up the work generally after it has been set

out by the boss framer. There are several methods of witnessing work by aid of the scratch awl which I show herewith, in Fig. 226; but, besides these, the work is sometimes witnessed with a pencil—blue, black or red; the black being used for mortises, the blue for tenons, and the red for gains or squared surfaces.

The end of the mortises and shoulders of tenons may be witnesses in the same manner, as shown in Fig. 226, using the pencil in lieu of scratch awl.

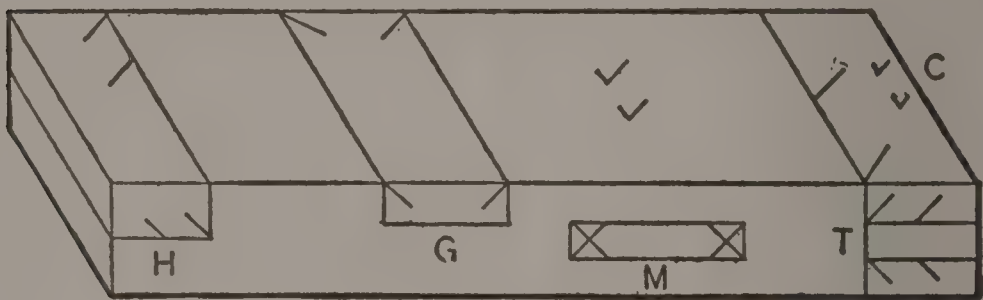


Fig. 227.

In this diagram the letter G represents a gain, M is a mortise and T is a tenon, the short diagonal marks w in the upper piece being the witness marks. The sketch shows four different methods of witness marking which are employed by most workmen, while numerous combinations of these four methods are also often used.

The best of these witness marks are those used on the timber marked F, though it has the disadvantage of being cut away when the mortise is beaten or the tenon cut, so that should a blunder

be made in the length of mortise or shoulder of tenon, it will be difficult to place the fault on the right person.

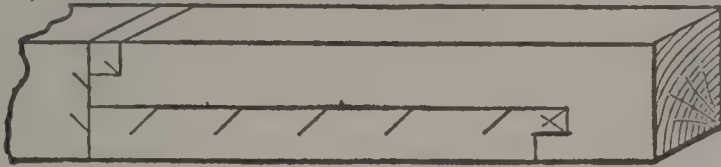


Fig. 228.

Another method of witnessing, and a very good one too, is shown in Fig. 227. T shows the tenon, M a mortise, A a gain, and H a halving. In this case it will be almost impossible to get astray if the workmen following the boss framer will only make himself acquainted with the system.

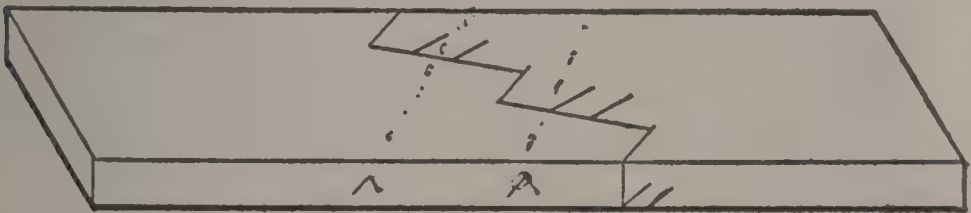


Fig. 229.

In Fig. 228 I show a method of witnessing a splice, and this, I think, will be readily understood. Another splice, with the manner of making it, is shown at Fig. 229, also the points where holes may be bored to receive bolts when such are to be bolted together for strength. The direction of the bolts is also shown. At Fig. 230 I show how

to make witness mark to cut a shoulder on a brace. This brace shows two bevels, simply to indicate that no matter what the bevels may be the marks show the shoulders. The letter C is the shorter bevel. The lines A A marked off the sketch, Fig. 231, show how a line or scratch made by mistake may be marked so that it may be known as a line not to be used.

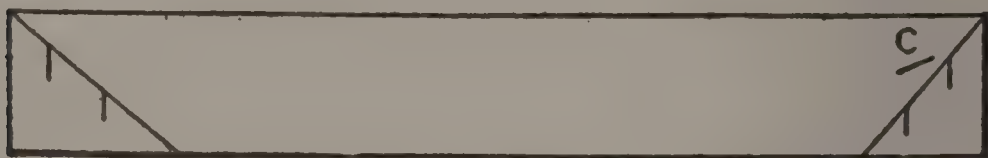


Fig. 230.

These witness marks are ample to instruct the workman in their uses, and though the examples given do not nearly cover the whole ground where such marks are required, they show the system and the keen workman will apply them in their proper places whenever it is necessary.

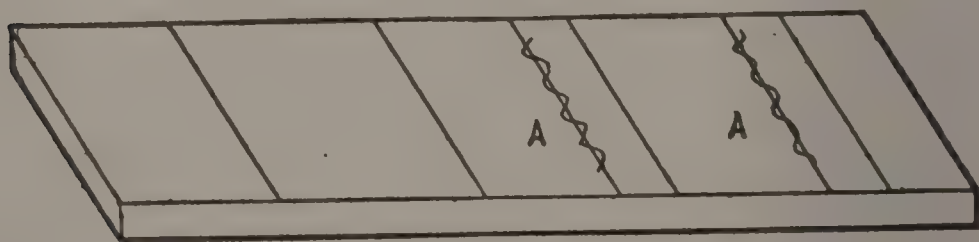


Fig. 231.

Mortises and tenons are usually laid out with the steel square, but it is not the best or speediest way, though the square is always at hand and

ready for use, and without a knowledge of its use for this purpose the workman will not be fully equipped for laying out a frame. Following an authority on the subject of laying out work by the steel square "the ends of the mortise are first struck as indicated at A and B, Fig. 232, and while the square is in the position indicated the mark C is made for the working side of the mortise, which is always the narrower side unless the

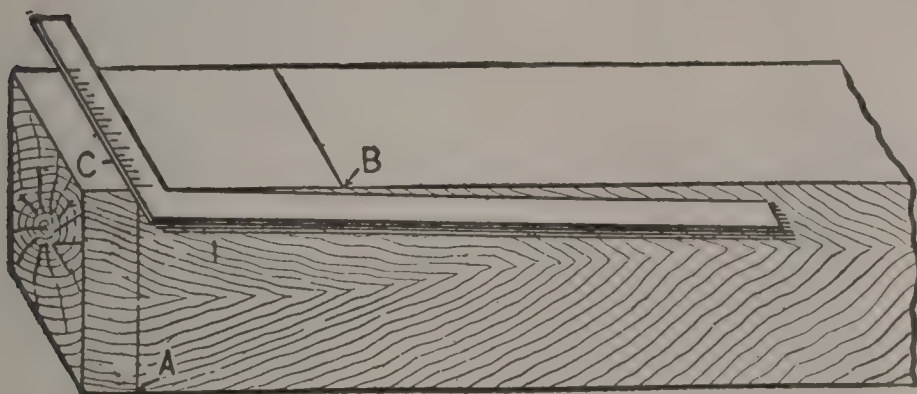


Fig. 232.

two are equal. In practice it is best to mark the cut off at the end of the timber first, or if it does not need cutting off, place the square over the end of the stick, and mark back along the blade the $1\frac{1}{2}$, 2 or 3 inches required for the shoulder. This makes sure that there is no projecting corners to give trouble later on.

If a tenon is being struck the same method is followed, going entirely around the stick but working in both directions from the face corner. The

ends of the mortise or shoulder of the tenon being thus treated, the sides are marked by reversing the square, placing the inside of the blade at E, Fig. 233, fair with the mark C previously made, and taking the same distance—in this case 2 inches—on the tongue of the square, as shown at B. Now by holding the square firmly with the thumb and fingers of the left hand both sides of the tenon can be marked, but great care is necessary to pre-

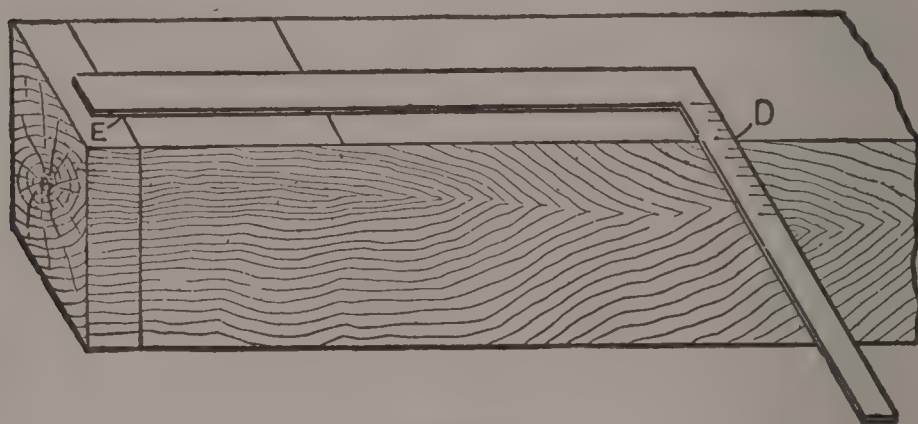


Fig. 233.

vent the slipping of the square. If there is any wane on the stick it is hard to tell when the mark D is exactly in line with the vertical face of the timber, and this matter must be determined by sighting down the side of the stick. It is also necessary to drop the blade of the square a little further, as at B, when squaring across a “wany stick.”

In every heavy timber framing a bridge framing steel square could be employed. These have

a blade three inches wide and a tongue one and a half inches wide. The blade is used to lay out mortises and tenons of three-inch dimensions. There is a slot one inch wide cut down the center of the blade, the slot is twenty-one inches long and it may be used on one inside edge to make a two-inch mortise or tenon; this is done by using one outside edge and one inside edge. These squares are made by Sargent & Co., of New York, and cost from \$2.50 to \$5.00 each. The squares are very handy for bridge builders and for framing all kinds of heavy timber.

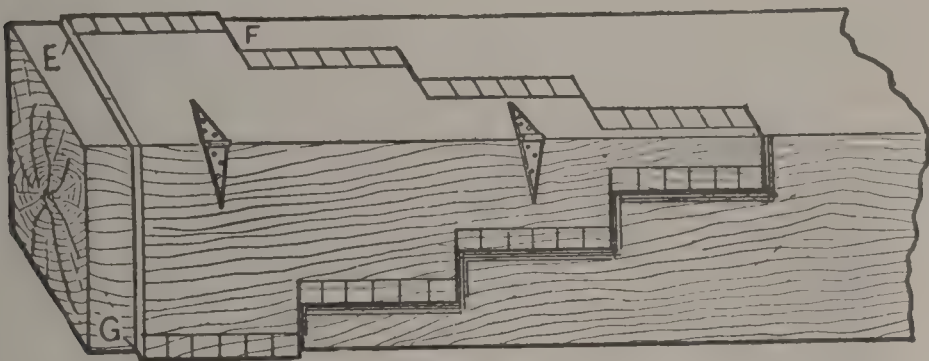


Fig. 234.

A kind of templet or guide is made use of sometimes, for laying out work, it is much handier, and easier to work with than the square, and will aid in laying out work much more rapidly. These templets are made in both wood and metal. They are hinged at the angle as shown in the sketches herewith, so they may work easily over wany edges or can be folded together and stowed away in a tool chest.

Where there is much framing of a like character to do, it is always best to make a sheet iron templet, as the rubbing of the scratch awl against the working edges of a wooden brass bound one will wear away the surface and the tenons and mortises will not be the correct sizes.

Mr. Hobart, in *Carpentry and Building*, describes these templets—the wooden ones—and adds a fair description of them and the way to use them, and I reproduce in brief a portion of his article on the subject: “The tool may be seen in two positions on the squared timber at Figs. 234 and 235. The tool is made of well seasoned wood $\frac{1}{4}$ in. thick, three thicknesses being glued up to form a board 8 inches wide by 24 inches long. The boards are then mitred together lengthwise, as shown, and a pair of ornamental brass hinges put on, these being clearly indicated in the sketches. Each part of the board is then notched into four steps of 6 inches each, being made $1\frac{1}{2}$, 3, 6 and 8 inches respectively. The other side of the tool is divided into 4, 6 and 8 inch steps, each 6 inches long. If much heavy work is to be laid out it will pay to make one side 1 inch wider, thus securing $1\frac{1}{2}$, 3, 6 and 9 inch steps on that side. The notched edges of the board are finished with a great deal of exactness, and after cutting a little scant the edge is bound with a heavy strip of sheet brass, which is shaped and screwed to the marking edge. The marking edge, and the

end as well, is marked off in inches and quarters, the same as a framing square, and this proves a great convenience when using the tool.

In order to lay out a mortise, slide the tool along until the end comes flush with the longest corner; then mark the end of the mortise, as at E of Fig. 234. At the same time mark the other end of the mortise, F, Fig. 234; then slide back the marker and strike that line after having first struck the line E. Next reverse the tool and select

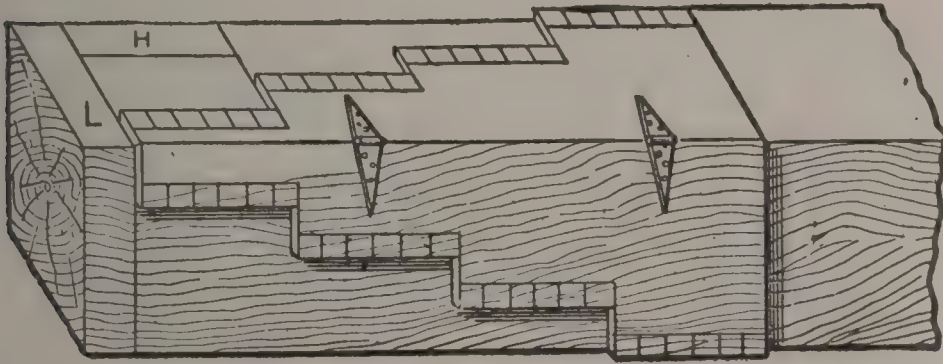


Fig. 235.

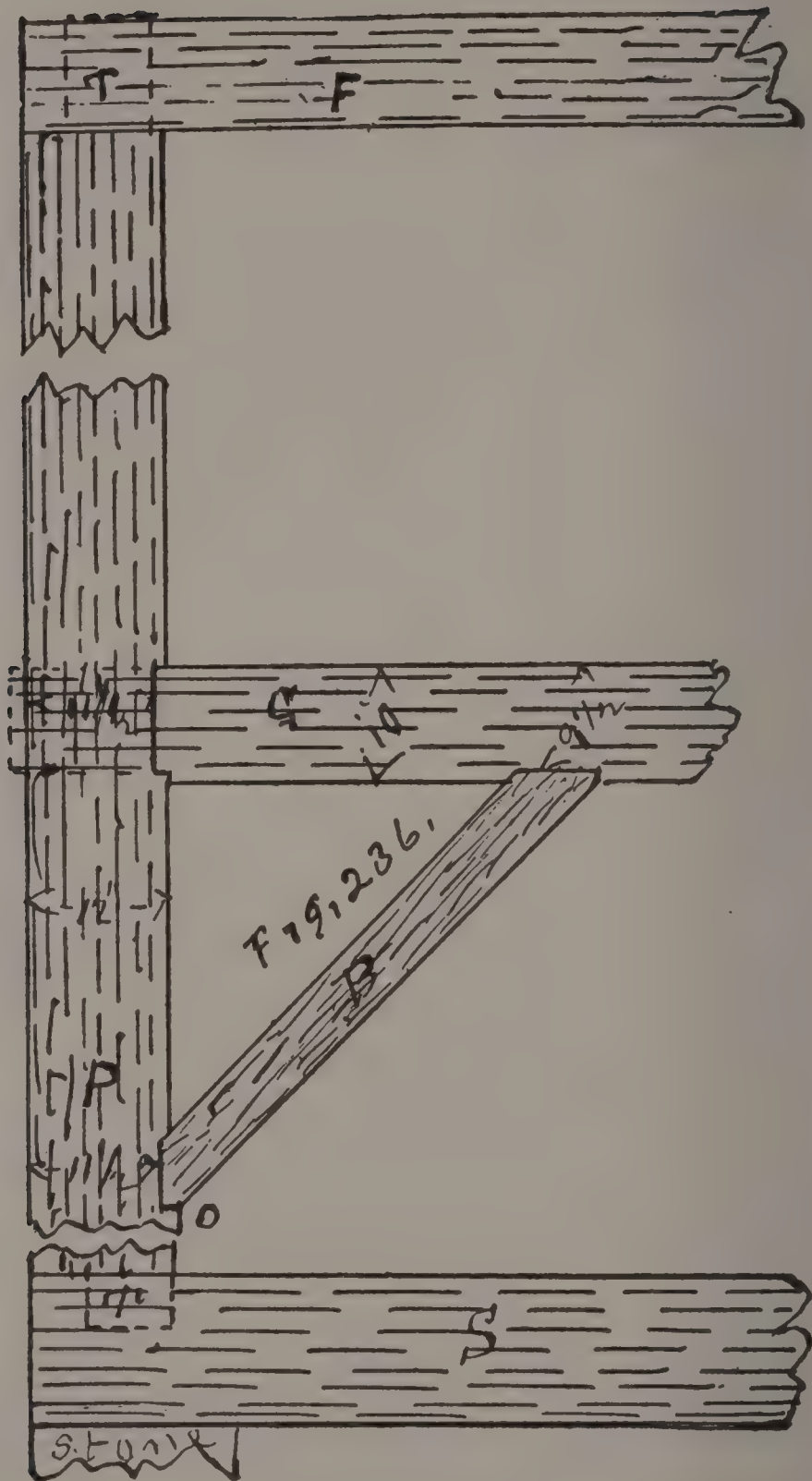
the width of shoulder required—2 inches in this case—and mark alongside the board on the timber. This fixes one side of the mortise or tenon, and a mark alongside the right width of tool, H, Fig. 235, finishes that mortise in very quick time.” Apart from this description, the workman will find in making use of this tool many places where it can be employed to advantage. If the whole tool was constructed of metal, it would not cost any more than if made of wood, as described in

the foregoing, and it would be neater, lighter, much more compact, and would last for all time.

While it is true that this templet is a great help in rapid framing and while in some cases where the timber is wany or lacking on the arrises something of the kind is necessary. Where the writer has met with wany timber he has often tacked a planed board on the side of the timber to be worked keeping the upper edge even with the top of the timber, then the square can be used for making over as the board forms a good surface to work the square from. When the templet is used, the necessity of the board is done away with, as the vertical portion of it takes the place of the board. The method of using the square for cutting rafters, braces, and other angular work, has been shown and described elsewhere, so I drop the matter of the square for the present.

There is one matter in framing that I do not think has ever been described or properly illustrated, and that is the question of "boxing." Non-framer may not know what the term "boxing" means; but every "old hand" at the business has, no doubt, a vivid recollection of the term and its uses. "Boxing" in framing may be described as preparing a true real square with the jaws of the mortise for the shoulders of the tenon to butt solidly against. To accomplish this often requires the removal of portions of the timber before a flat square surface is found, and this may reduce

the thickness of the timber operated upon. If we suppose four or five posts on the side of a building, and these posts are supposed to be 12 x 12 inches in section and in preparing these posts to receive the tenons it is necessary to remove over the face of each mortise one-quarter of an inch or more, and the girts or connecting timbers have their shoulders cut to suit the 12-inch posts, it will be seen that the length of the building at the line of girts will be less than intended. If forced into mortises made the proper distance apart in the sills, the outside posts will not be plumb and it will be found impossible to make the plates fit in place, as the mortises on the ends will be found too far apart, and this would lead to all sorts of trouble and vexation. In boxing, we suppose the posts to be, say $11\frac{1}{2}$ inches instead of 12 inches. This allows half an inch for boxing, and this necessitates the girt between each set of posts, to be cut one inch longer between shoulders than if no boxing was prepared. In cases where posts are pierced on both faces and boxed, the post where the tenons enter, if directly opposite, may have to be reduced to 11 inches and must be accounted for on that basis. The young framer must be particular about the boxing and the necessary reduction of timbers when laying off his lengths of girts or bracing timbers, if not he will be sure to get into trouble or botch the job.



I show, at Fig. 236, how the boxing is done, and how to lengthen the timber between shoulders to meet the requirements of the case. G shows the girt where it is boxed into the post P, and

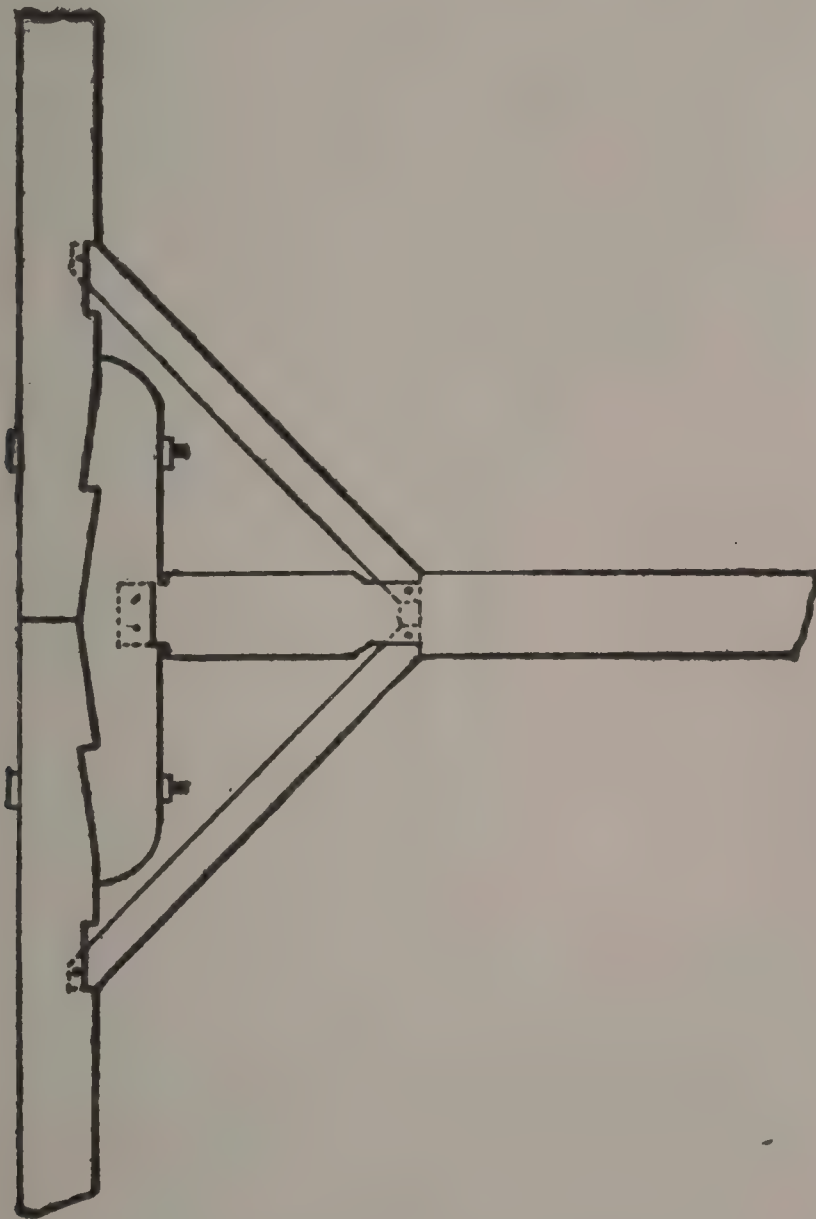


Fig. 237.

F S shows the sill and plate with the tenons T T rehashed for the shorter mortises. The brace B shows how it is butted at both ends against the boxing in the post and girt. The points, or "toes,"

of the brace are squared off so as to rest against the half inch shoulder which is caused by the boxing.

At Fig. 237 I show a post boxed on both sides for braces; also a scarfing which ties two beams together, the joints of the beams being directly over the center of the post. It will be noticed the

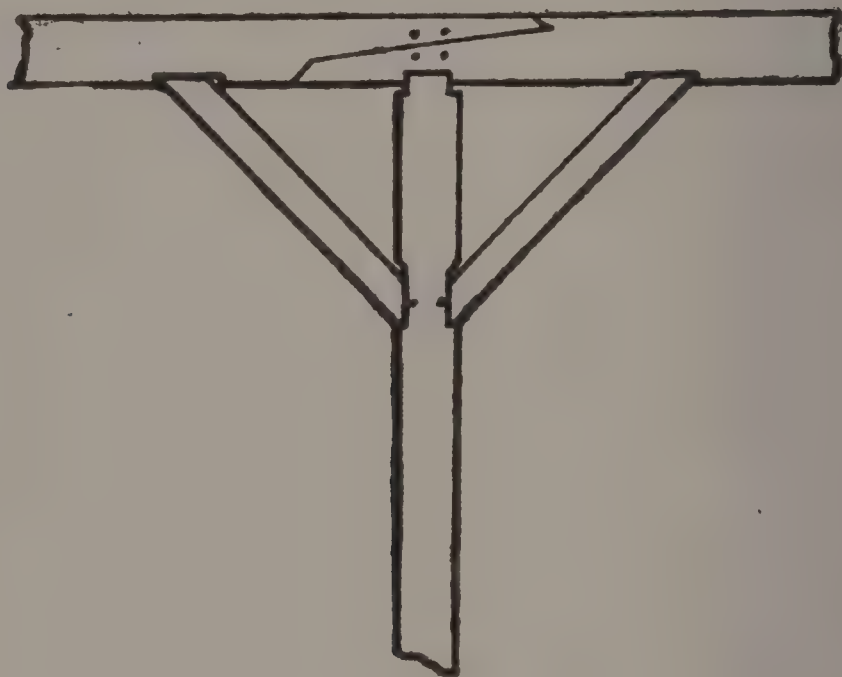


Fig. 238.

scarfing block grapples both beams and is bolted at both ends. The braces and post are draw-bored and pinned as shown by the round dots on the diagram. The scarfing block or bolster, in cases of this kind where there is a heavy weight above to carry, should be of hardwood, oak, maple or other suitable strong wood.

The next illustration, Fig. 238, shows a double boxed post with braces carrying a scarfed beam.

The tenon on the top of the post passes through the splice holding the two beams together. It is drawbored and pinned together through both splices.

Fig. 239 exhibits another boxed post, braces, splice and beams. The post is double pinned to both beams, which are bolted together. These two illustrations, Figs. 238 and 239, are good examples

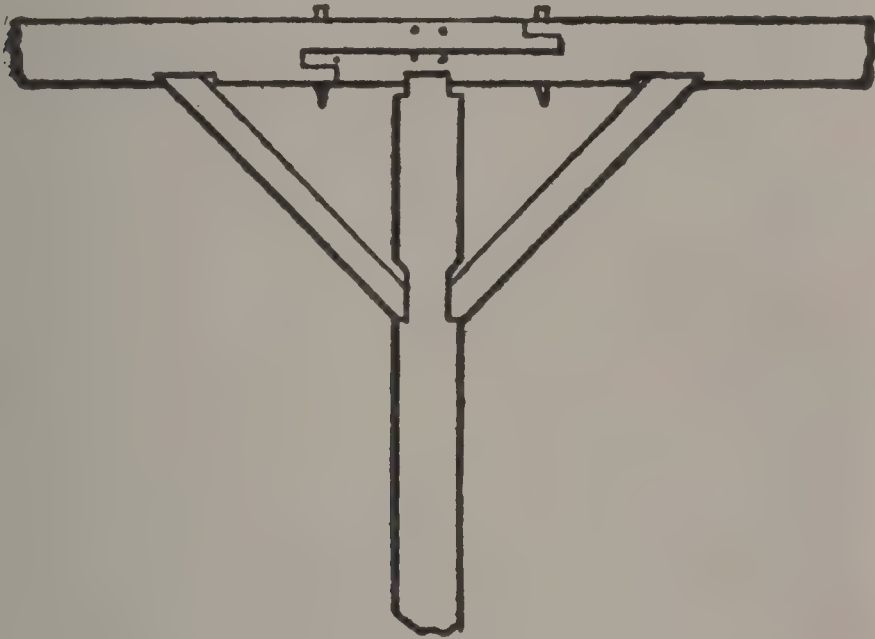


Fig. 239.

of spliced beam support, and are often made use of in warehouses, barns and other similar structures.

At Fig. 240 I show the usual manner of framing a barn about 30 x 40 feet, and 16 or 18 feet high. Fig. 241 exhibits a portion of the end of the building, with rafters, purlins and collar beam. The center post shown is supposed to be boxed on

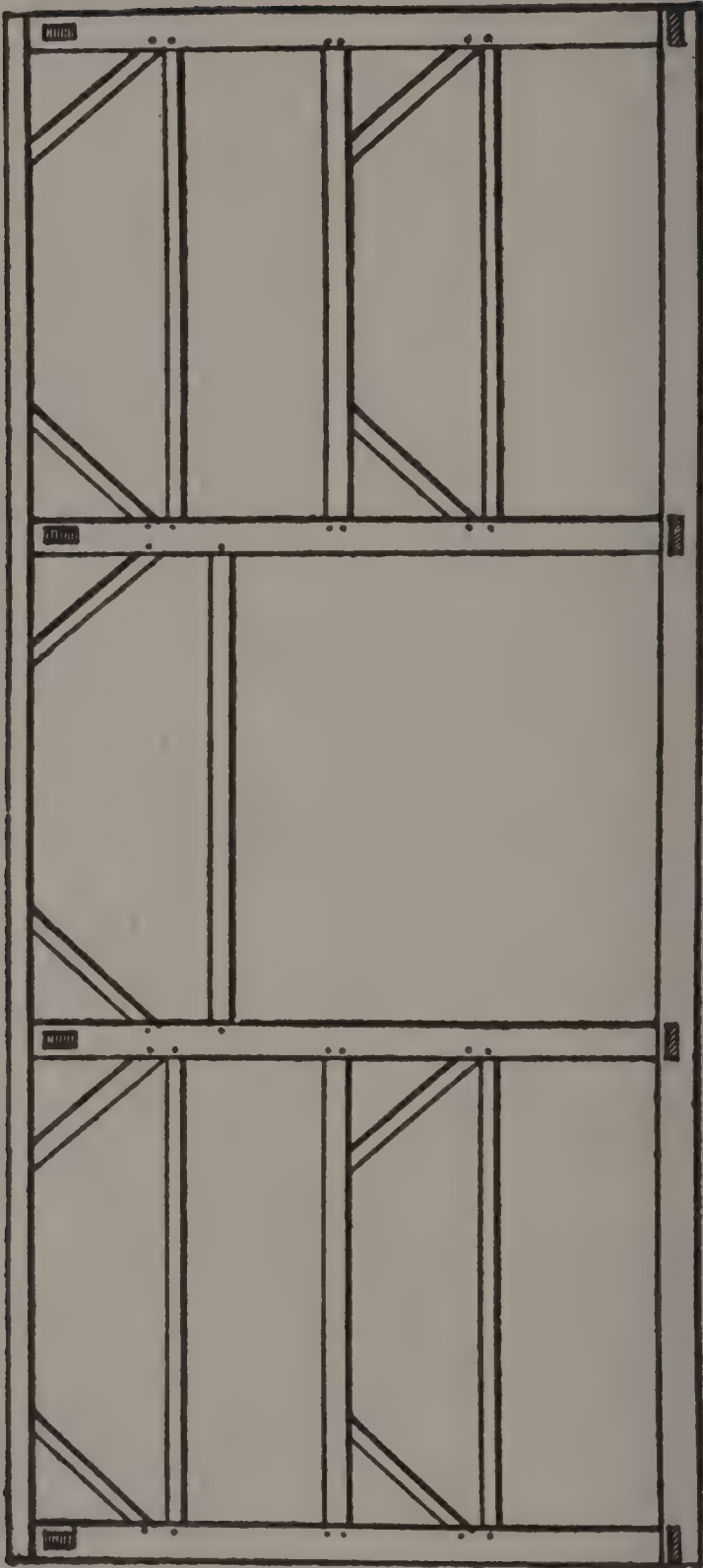


Fig. 240.

both sides, but the drawing is of too small a scale to show the boxing on either post, sill or plate.

The timbers for a building like this are usually about the following dimensions: Sills, 12 in. x 12

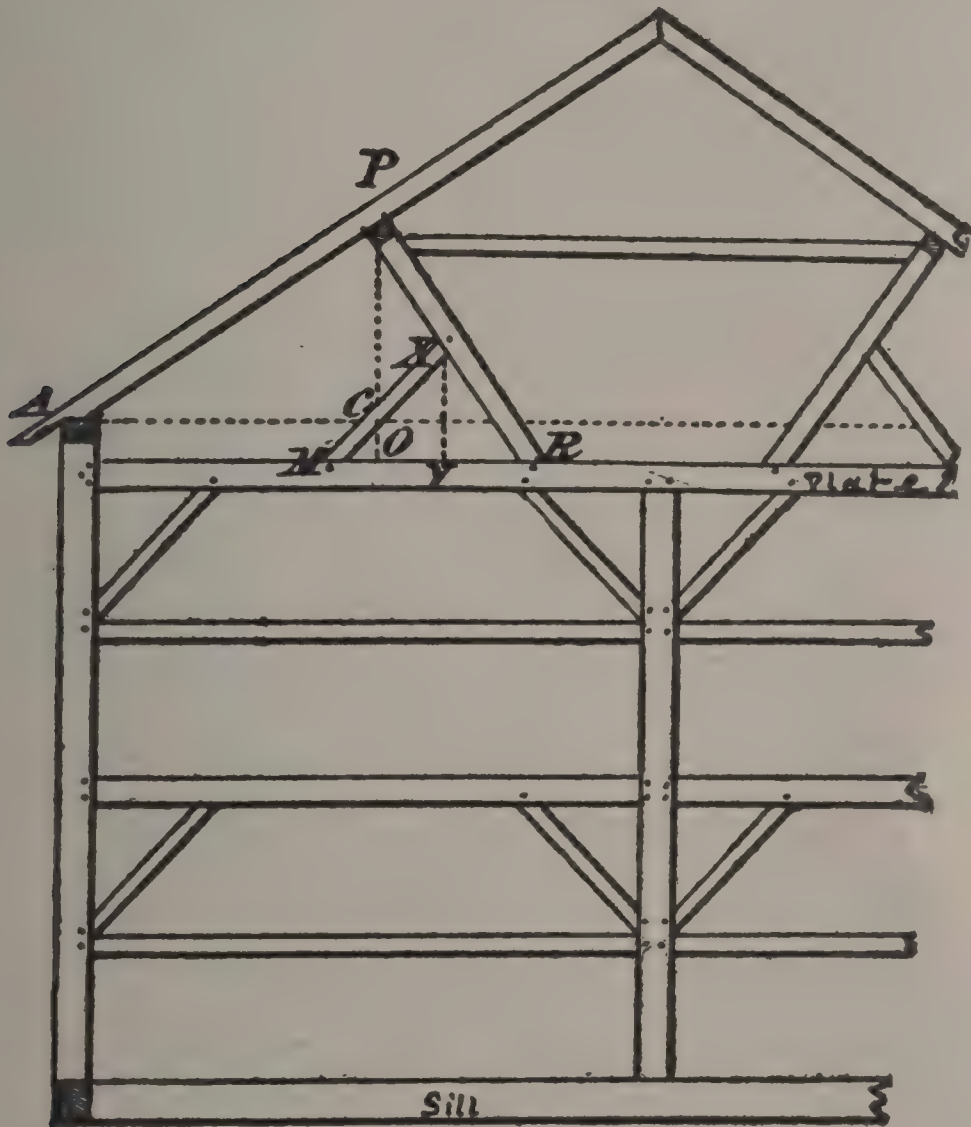


Fig. 241.

in.; posts and large girders, 10 in. x 10 in.; plates and girder over drive doors, 8 in. x 10 in.; purlin plates, 6 in. x 6 in.; purlin posts and small girders, 6 in. x 8 in.; braces, 4 in. x 4 in.; rafters, collar

beams, etc., 2 in. x 6 in. These dimensions may, of course, be changed to suit circumstances and conditions. All mortises in the heavy timber may be three inches and of such length as the sizes of the timber will allow. Draw-bore holes for pine may be from 1 in. to 1½ in. in diameter, but should never exceed the latter size. Two draw pins may be used in mortise and tenons when the tenon is 8 inches or more wide. Less than that width, one pin will be quite enough. In laying out draw-bore holes have them two inches from the side of the mortise, then on the tenons they should be an eighth or a quarter of an inch less than two inches from the shoulder, then if they are just two inches from the boxing or the face of the mortise, the pins, when driven in, will draw the shoulders snug up to the bearing. In making draw-bore holes care must be taken not to make a mistake and place the hole where, when the pin is driven home, the joint will be forced open instead of drawn closer. A little thought when the holes are laid out will prevent the hole from being a *push-bore* instead of a draw-bore.

The braces are framed on a regular 3-foot run; that is, the brace mortise in the girder is 3 feet from the shoulder of the girder, and the brace mortise in the post is 3 feet below the girder mortise.

In this building the roof is designed to have a third pitch; that is, the peak of the roof would be

one-third the width of the building higher than the top of the plates, provided the rafters were closely fitted to the plates at their outer surfaces.

In order to give strength to the mortises for the upper end girders, these girders are framed into the corner post several inches below the shoulders of the post, say 4 inches; the thickness of the plates being 8 inches it will be perceived that the dotted line, AB, drawn from the outer and upper corner of one plate to the outer and upper corner of the other is just 1 ft. higher than the upper surface of the girder.

The purlin plates should always be placed under the middle of the rafters, and the purlin posts, being always framed square with the purlin plates, the bevel at the foot of these posts will always be the same as the upper end bevel of the rafters; also, the bevel at each end of the gable-end girder will be the same, since the two girders being parallel, and the purlin post intersecting them, the length of the gable-end girder will be equal to half the width of the building, less 18 inches; 6 inches being allowed for half the thickness of the purlin posts, and 6 inches more at each end for bringing it down below the shoulders of the posts.

In order to obtain the proper length of the purlin posts, examine Fig. 241. Let the point P represent the middle point of the rafter, and let the dotted line PO be drawn square with AB; then will AC be the $\frac{1}{4}$ of AB, or $7\frac{1}{2}$ feet, and PC, half

the rise of the roof, will be 5 feet, and PO 6 feet. The purlin post being square with the rafter, and PO being square with AB, we can assume that PR would be the rafter of another roof of the same pitch as this one, provided PO were half its width, and OR its rise. This demonstration determines also the place of the purlin post mortise in the girder; for AC being $7\frac{1}{2}$ feet, and OR being 4 feet, by adding these together, we find the point R, the middle of the mortise, to be $11\frac{1}{2}$ feet from the outside of the building; and the length of the mortise being $7\frac{1}{4}$ inches, the distance of the end of the mortise, next the center of the building, is 11 feet $9\frac{5}{8}$ inches from the outside of the building.

The brace of the purlin post must next be framed, and also the mortise for it, one in the purlin post and the other in the girder. The length of the brace and the lower end bevel of it will be the same as in a regular three feet run; and the upper end bevel would also be the same, provided the purlin post were to stand perpendicular to the girder; but, being square with the rafter, it departs further and further from a perpendicular, as the rafter approaches nearer and nearer towards a perpendicular; and the upper end bevel of the brace varies accordingly, approaching nearer and nearer to a right angle as the bevels at the foot of the post, or, what is the same thing, the upper end bevel of the rafter departs further and further from a right angle. Hence, the bevel

at the top of this brace is a compound bevel, found by adding the lower end bevel of the brace to the upper end bevel of the rafter.

In framing the mortises for the purlin post braces, it is to be observed, also, that if the purlin post was perpendicular to the girder, the mortises would each of them be 3 feet from the heel of the post; and the sharper the pitch of the roof, the greater this distance will be. Hence the true distance on the girder for the purlin post brace mortise is found by adding to 3 feet the rise of the roof in running 3 feet; which, in this pitch of 8 inches to the foot, is two feet more, making 5 feet, the true distance of the furthest end of the mortise from the heel of the purlin post.

The place in the purlin post for the mortise for the upper end of the brace may be found from the rafter table, by assuming that Rx would be the rafter of another roof of the same pitch as this one, if xy were half the width, and yR the rise. For then, since xy equals 3 feet, we should have width of building equal 6 feet, rise of rafter, one-third pitch, gives yR equal 2 feet; and hence xR would equal 3 feet 7.26 inches, the true distance of the upper end of the mortise from the heel of the purlin post.

Figs. 242 and 243 are designed to illustrate the manner of finding the upper end bevel of purlin post braces, to which reference is made from the preceding examples.

In Fig. 242, let AB represent the extreme length of the brace from toe to toe, the bevel at the foot having been already cut at the proper angle of 45

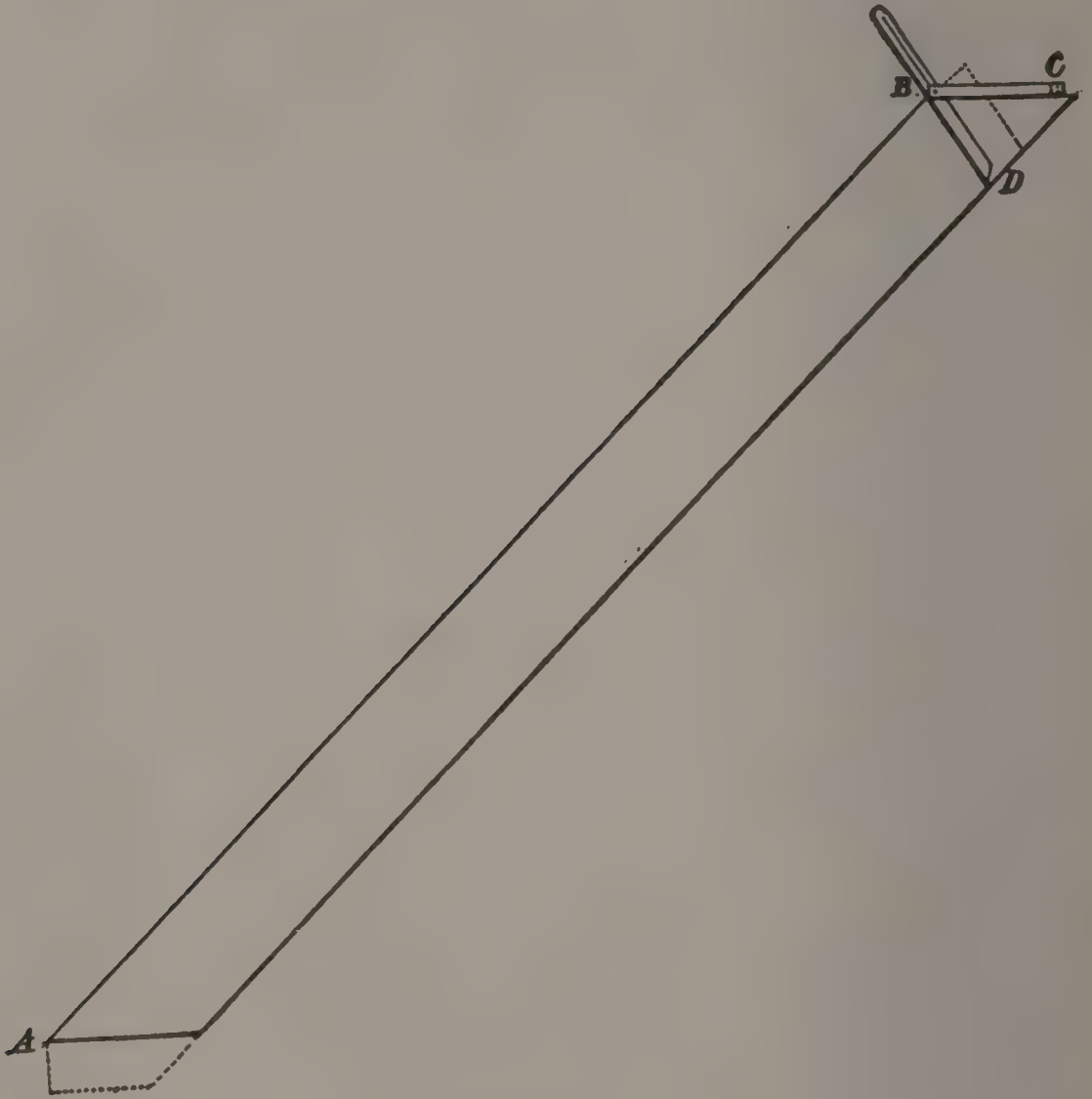


Fig. 242.

degrees. Draw BC at the top of the brace, at the same bevel; then set a bevel square to the bevel of the upper end of the rafter, and add that bevel to BC by placing the handle of the square upon

BC and drawing BD on the tongue. This is the bevel required.

Fig. 243 shows another method of obtaining the same bevel. Let the line AB represent the bevel at the foot of the brace, drawn at an angle of 45 degrees. Draw BD at right angles with AB, and draw BC perpendicular to AB, making two right-angled triangles. Then divide the base of the

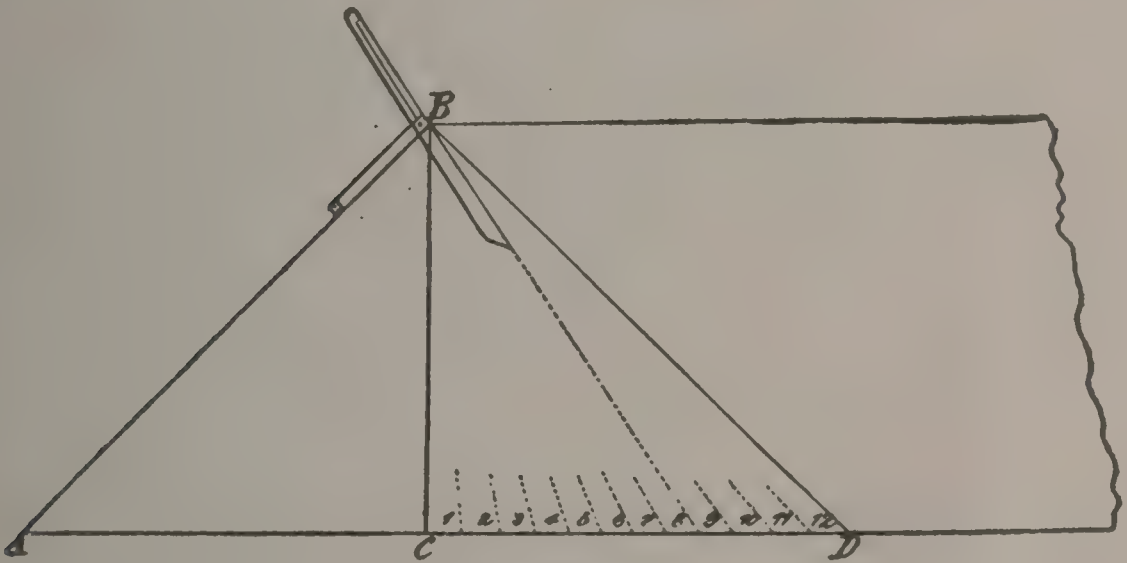


Fig. 243.

inner one of these triangles into 12 equal parts for the rise of the roof. Then place the bevel square upon the bevel AB at B and set it to the figure on the line CD, which corresponds with the pitch of the roof. This will set the square to the bevel required for the top of the brace. In this figure the bevel is not marked upon the brace, but the square is properly set for a pitch of 8 inches to the foot, or a one-third pitch. The square can now be placed upon the top of the brace, and the

bevel marked. These examples are taken from "Bell's Carpentry," an excellent work that was very popular forty or fifty years ago because of its reliability and exhaustiveness. There have been many improvements in framing, however, since this book was made, still it contains some things that have never been improved on.

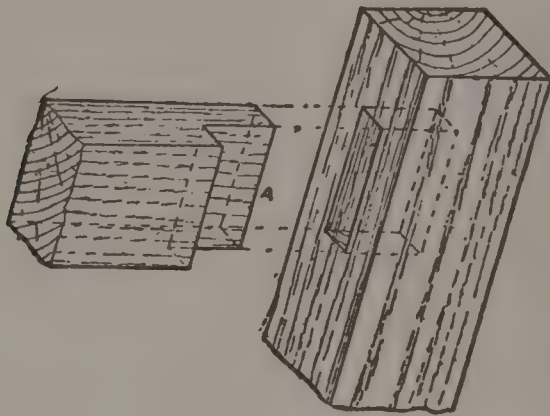


Fig. 244.

One style of mortise and tenon must not be overlooked, which is often employed in framing girts or girders, and that is the "bareface stub tenon," which I show at A in the illustration Fig. 244, where it will be seen that at one side of the tenon there is a shoulder. The other side not having a shoulder is thus said to be barefaced. Since it does not pass right through the post, it is known as a stub tenon. This form of tenon is used where one surface of the girt is to be flush with that of a post, the other side of the girt being set back from that of the post (as shown).

In Figs. 245 and 246 I show a couple of examples of mixed, heavy and light framing. These will

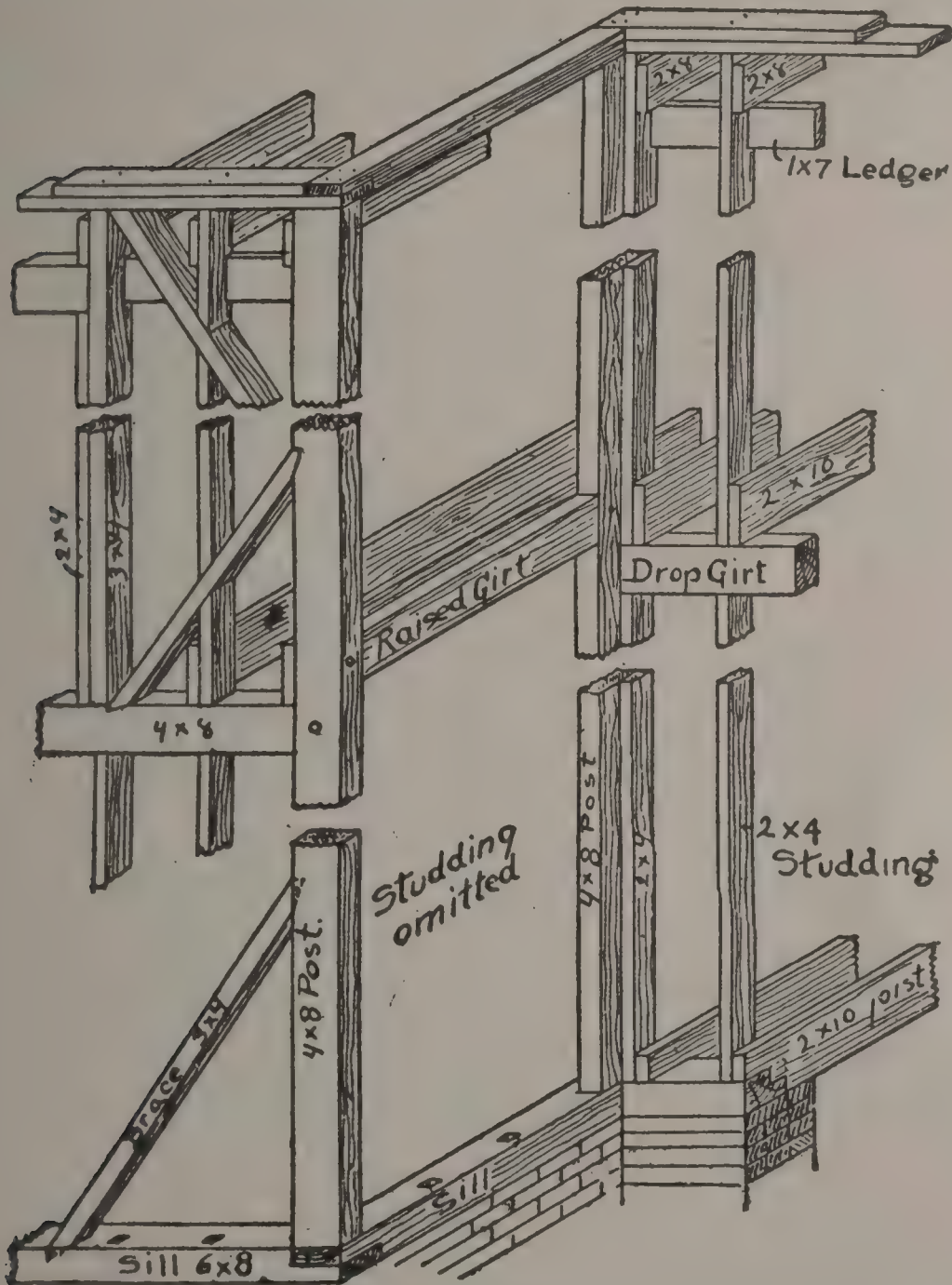


Fig. 245.

show how that style of work is done, and will, I am sure, prove of value to the learner.

trations and methods of preparing timber for floors, so I will not now enter at much length into this subject, but briefly give a few examples of such work, as I know from experience will prove of the greatest value to the general workman:

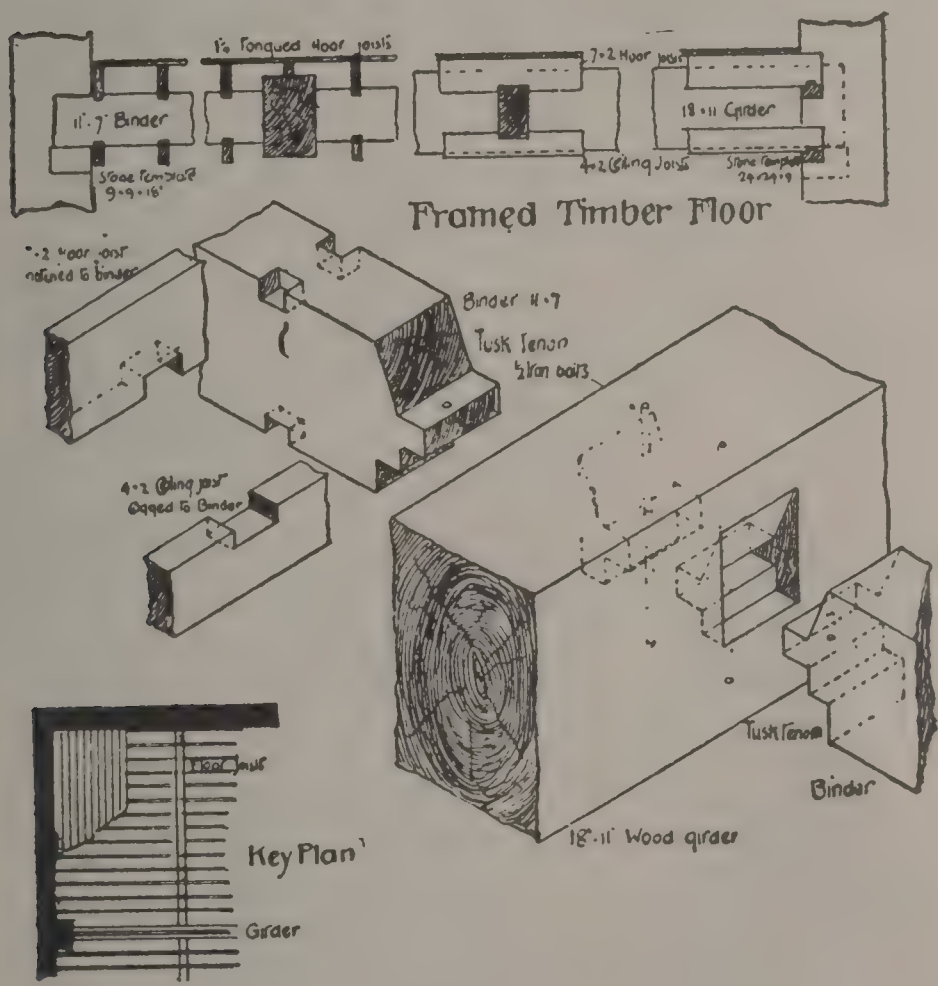


Fig. 247.

A general system of floor framing in timber alone is shown in Fig. 247, the whole floor being of wood. Fig. 248 exhibits a timber floor intended for a double surface. The upper series carry the ceiling joists. At Fig. 249 I show how a framed floor,

partly of wood and partly of iron, is usually put together in many localities. In Chicago and other places there is often a departure from this method, which is not always for the best. A double iron

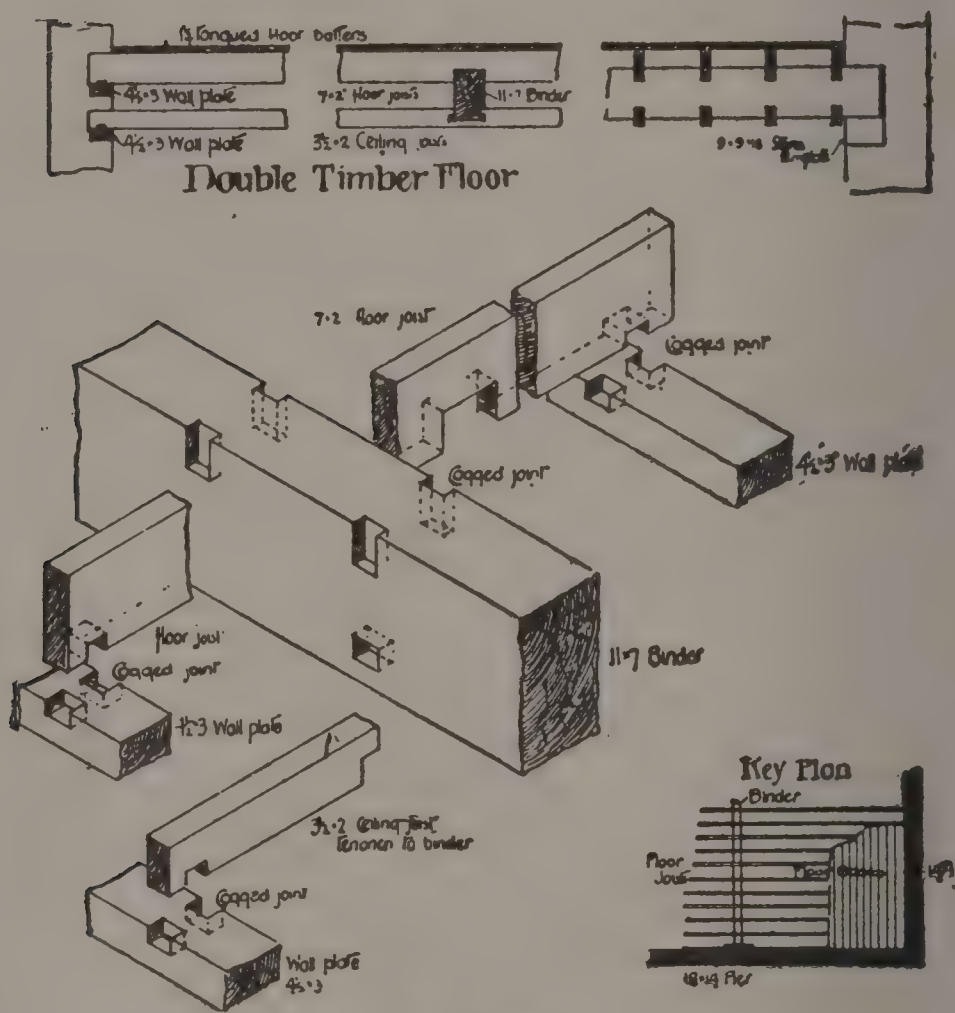


Fig. 248.

and timber floor is shown in Fig. 250, while a coal breeze or concrete floor with necessary steel girders is shown at Fig. 251. Fig. 252 shows a strongly reinforced concrete fireproof floor, capable of bearing great weights.

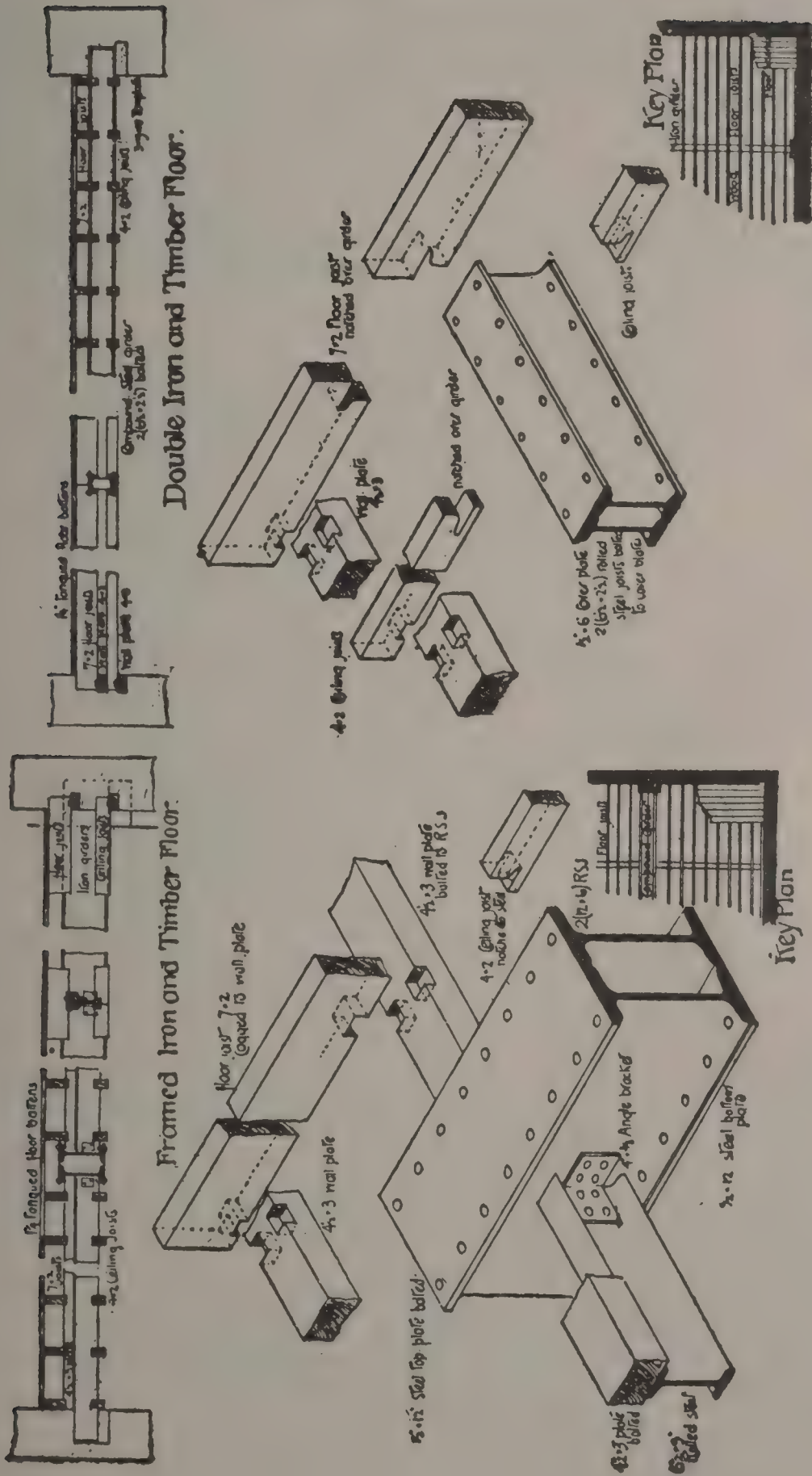
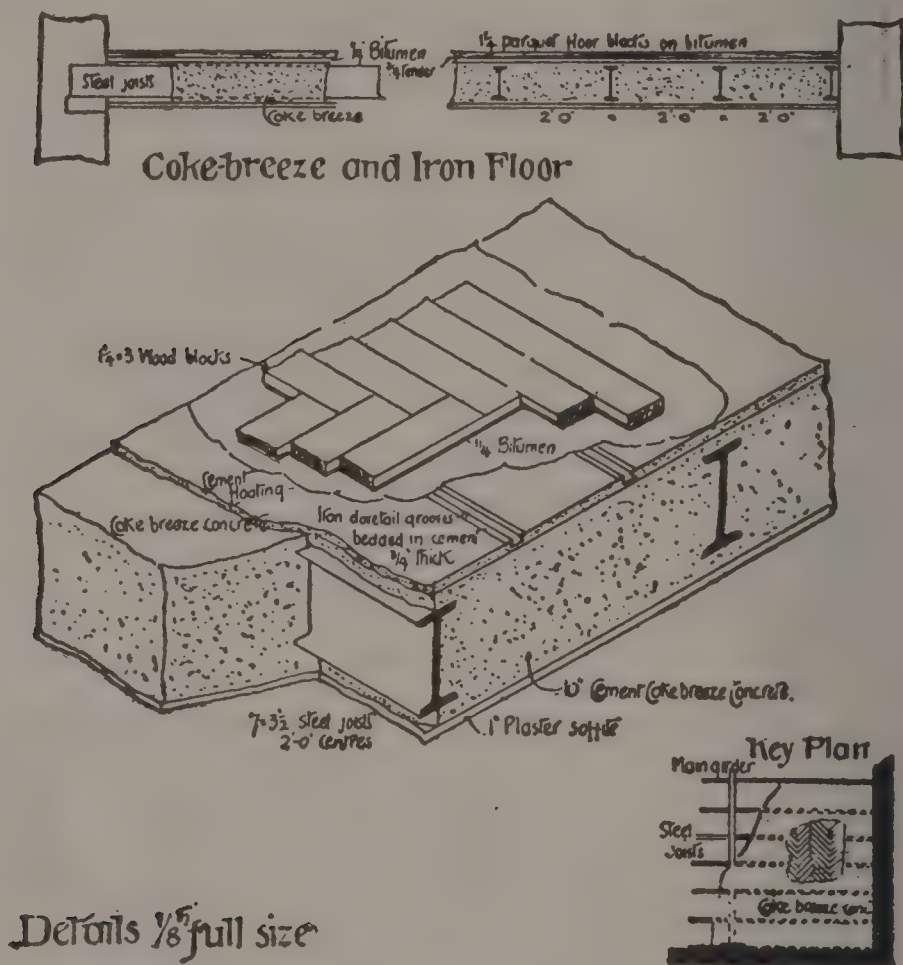


Fig. 250.

Fig. 249.

A few hints here regarding timbering floors, over and above what has been said, may not be out of place:



Details $\frac{1}{8}$ full size

Fig. 251.

When ceilings are fixed direct to bridging joists that are thicker than $2\frac{1}{2}$ in., banding fillets should be nailed on their bottom edges to fix the lathing to.

Ceiling joists in framed floors should be fixed to the binders. Notching or mortising the binder weakens it considerably.

Keep the ceiling joists $1\frac{1}{2}$ in. below the binder and counter lath the edge of the latter to afford key for plaster.

When the height is not sufficient to allow of the use of ceiling joists, notch the bridging joists 1

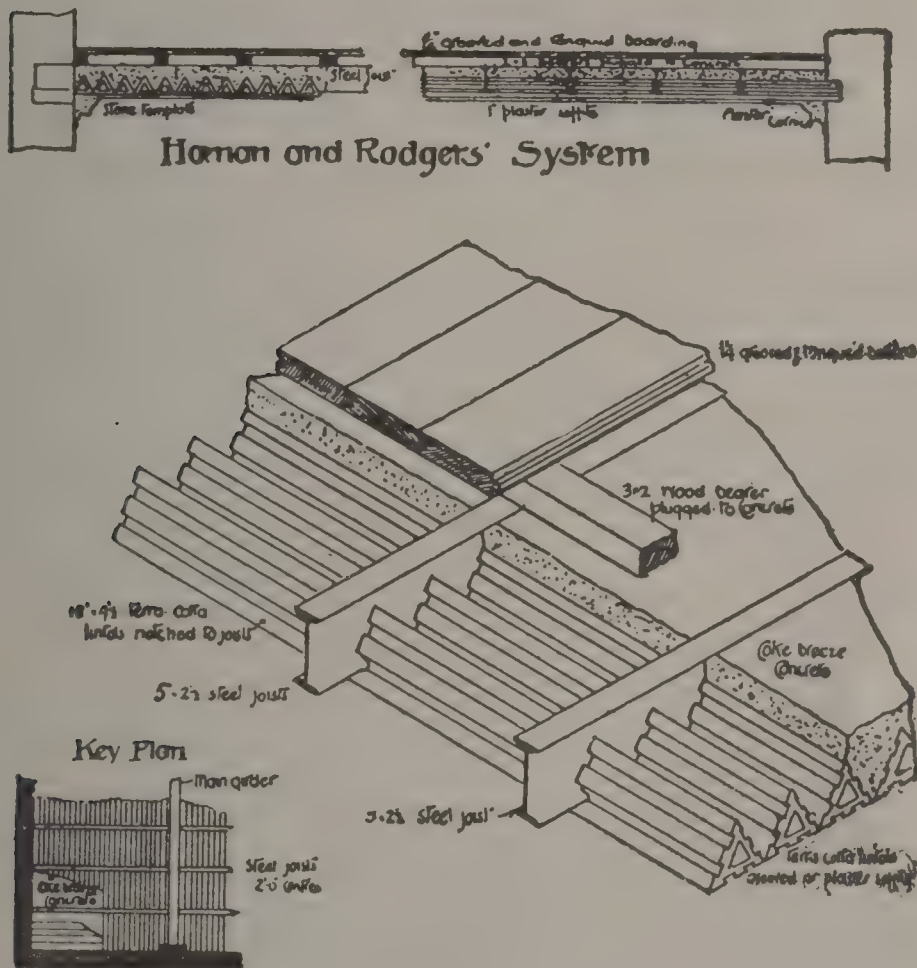


Fig. 252.

in. down on the binders, and lath and plaster direct. Also put in a row of plasterers' nails in the sides of the binder to form a key for the plaster, and plane and mould the visible portion of binder.

Every fourth or fifth bridge joist is well made 2 in. deeper than the rest, and the ceiling joists fixed thereto.

Pine is better than oak for ceiling joists.

To find the depth of ceiling joists, 2 in. thick, for any span, halve the bearing in feet; the result will be the depth in inches.

Ceiling joists should never exceed $2\frac{1}{4}$ in. in thickness, nor be less than $1\frac{3}{4}$ in. They should be spaced not more than 16 in. apart, center to center.

Ceiling joists should be thoroughly dry, or they will indicate their position first by dark and later by light stripes on the ceiling.

A flitched girder consists of a wrought iron plate placed between two timber flitches, and the three bolted together. The plate should be $\frac{1}{4}$ in. within each edge of the wood, so that the weight shall not be all thrown on it when the wood has shrunk.

When pine or spruce plates are fixed to the sides of iron girders for the purpose of carrying the ends of joists, they may be secured with straps in place of bolts with advantage in points of strength and economy.

Scantlings for girders of Baltic fir; distance apart, 10 ft., center to center:

10 ft. span=	9 in. x 7 in.	} and add an inch in each direction (breadth and depth) for every additional 2 ft. of span.
12 ft. span=	10 in. x 8 in.	

It is worse than useless to truss girders in their own depth.

Wood beams, when used as girders, should be cut down the middle, one of the flitches being reversed and the two then bolted together. This equalizes, if it does not increase, the strength, and at the same time affords an opportunity of seeing whether the heart is defective. The bolts should be placed mainly above the center line, and any placed below should be near the ends.

Wood girders for warehouses, factories, and similar buildings, are better unwrought. If it is desired to paint them, they should be cased with worked pine linings, fixed to $\frac{1}{2}$ in. furring pieces.

The formula for the strength of timber girders

$$\text{is } W = C \frac{b d^2}{L}$$

Where W = breaking weight in cwts.

L = span in feet

b = breadth in inches

d = depth of girder in inches

C = constant = 5 for oak, pitch pine,
and birch
= 4 for southern pine.

Load at center and beam supported only.

The maximum strength of a timber beam is obtained when the breadth is to the depth as 5 is to 7.

The illustration shown at Fig. 253 makes plain the method of constructing a double floor. The binder rests on a wall or posts. This makes a fine floor, and is in a measure sound proof.

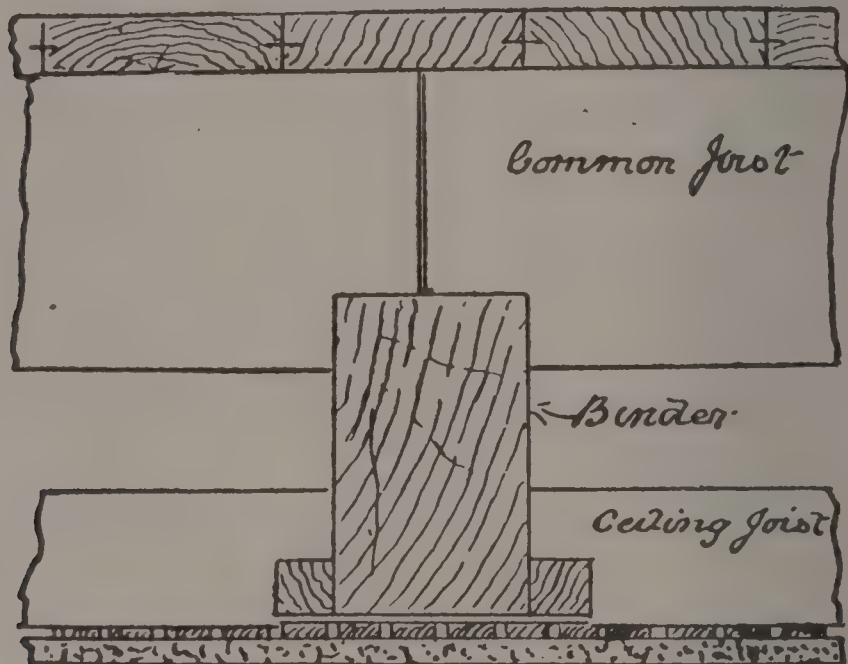


Fig. 253.

Figs. 254, 255, 256 and 257, which are borrowed from *Architecture and Building*—old series—will convey to the reader a number of excellent ideas as to the combination of iron and wood in floor framing.

Fig. 258 shows the manner usually adopted in preparing the floor timbers around a hearth, chimney breast, stair well hole, or openings for trap doors or similar work. The trimmers and headers are made with heavier timbers than the joists, and

the tail beams are let into the headers with either plain or tusk-tenons. Tusk-tenons, of course, are the best, but entail much labor and care. A tusk-tenon with a run-over top, is shown in Fig. 259.

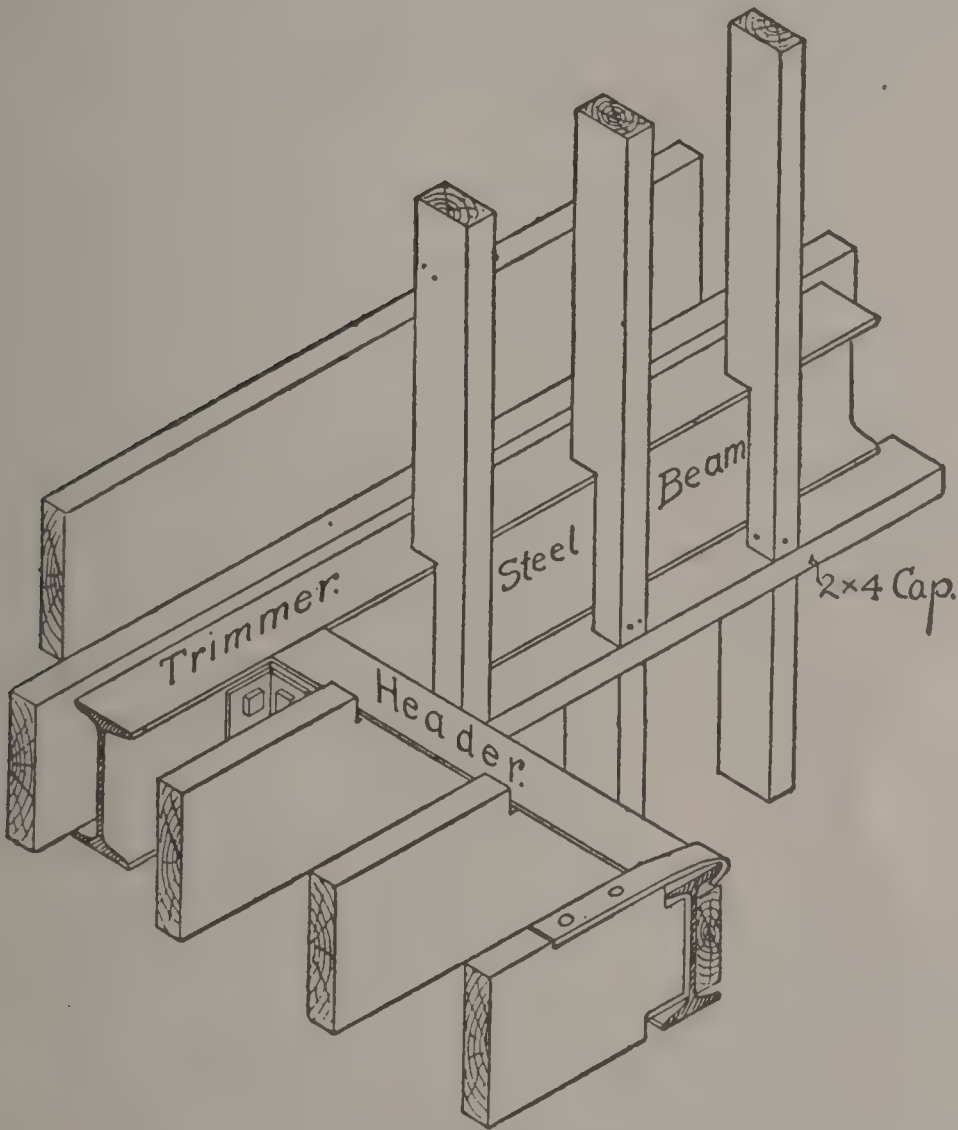


Fig. 254.

This makes a good clean joint for running over a girt or bearing timber, and can be nailed together over the joint as shown, thus holding the work so that it cannot spread. The tenon is shown at A.

There are various shapes of tusk-tenons, some of which are shown in the foregoing examples. I give below herewith a brief description of what I think makes the best kind of a tenon:

The usual rule for cutting a common tenon is to make it one-third the width of the timber and

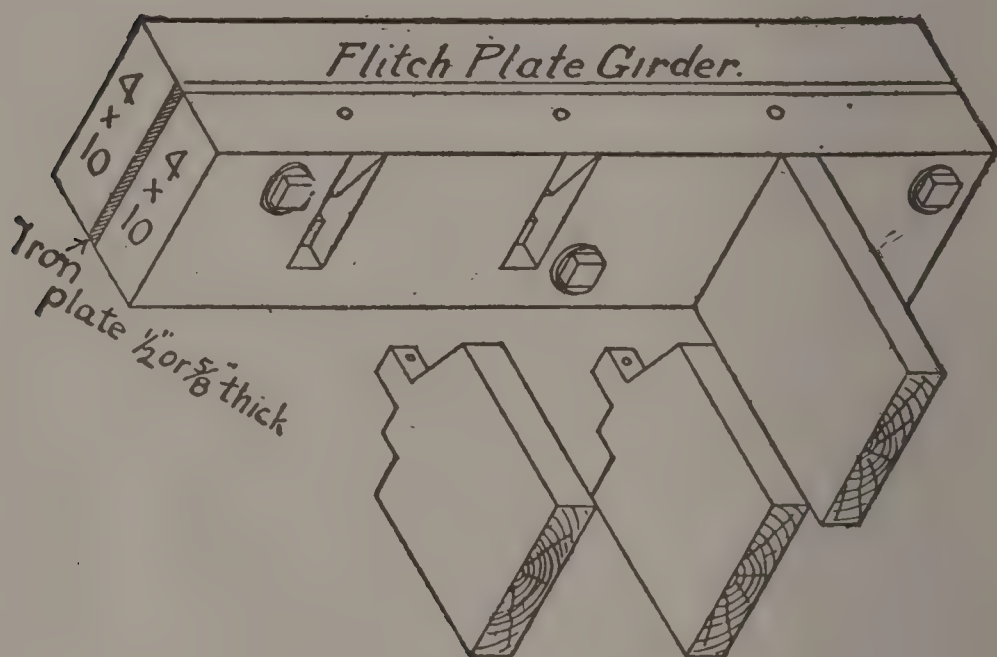


Fig. 255.

this rule should be followed as far as possible in designing a tusk-tenon. The projection of the tenon from the beam out of which it is cut is called its root, and the surfaces immediately adjacent to its root on the sides are called the shoulders.

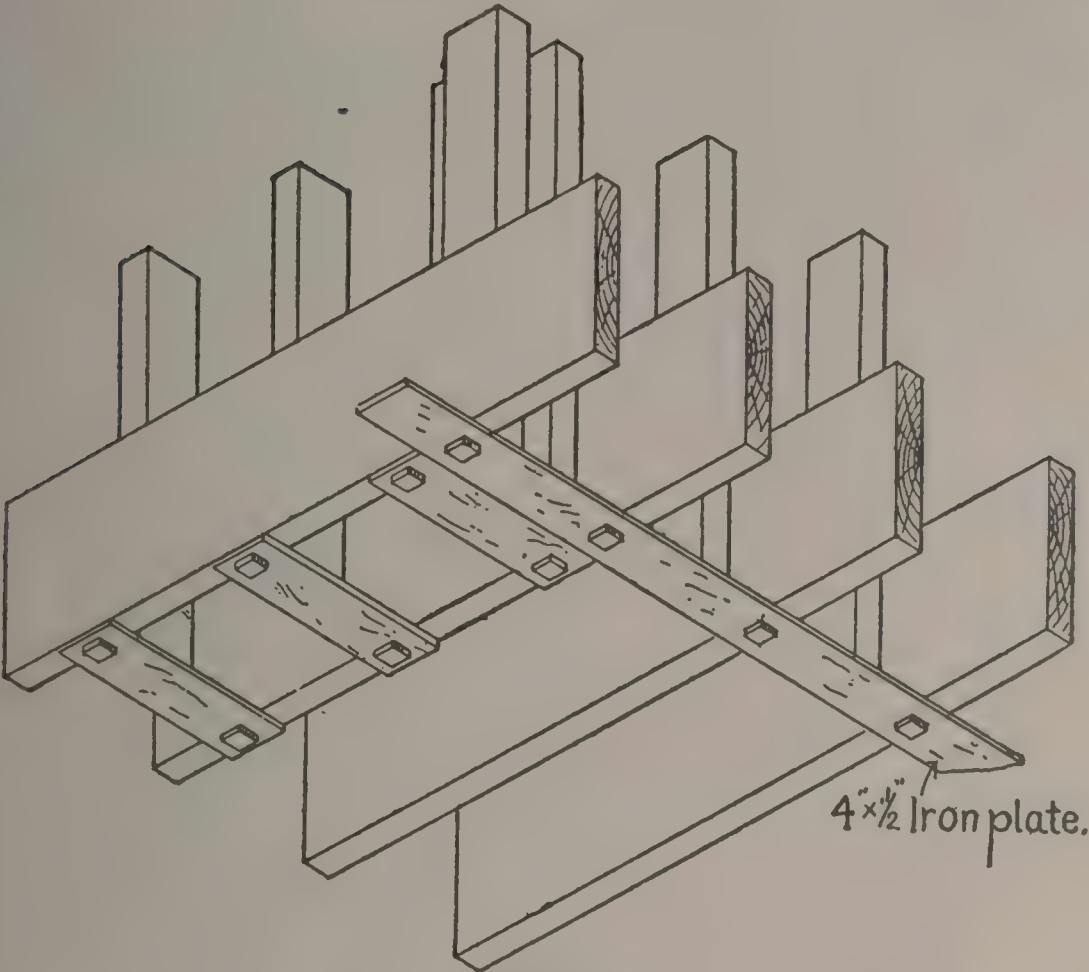


Fig. 256.

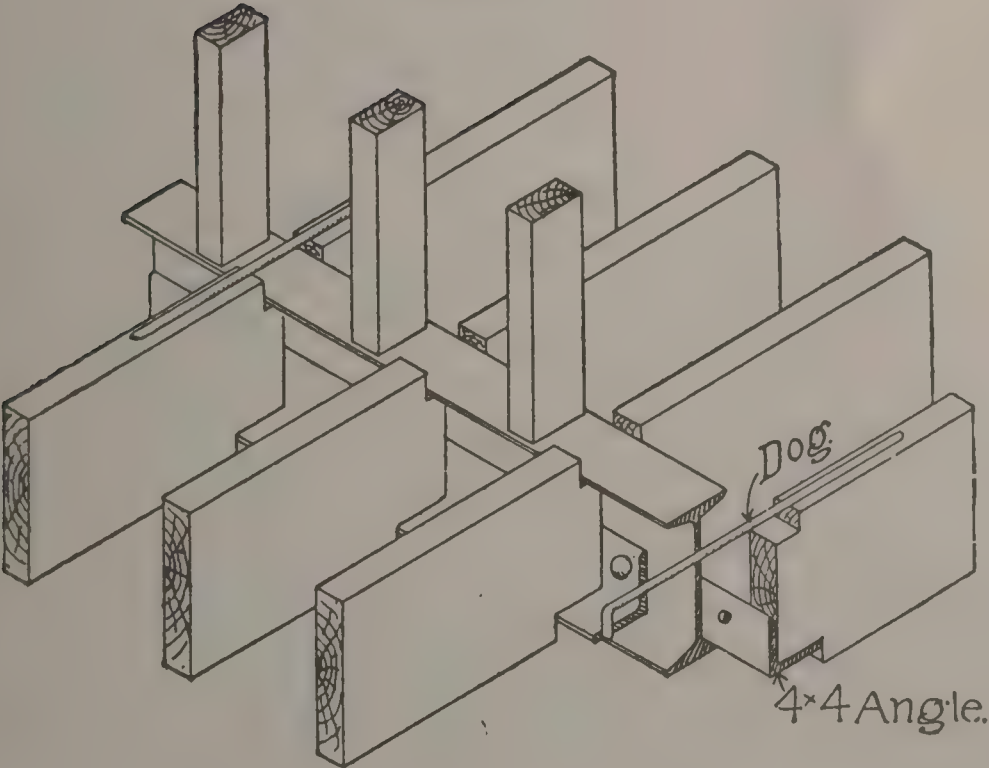


Fig. 257.

The tusk-tenon was devised in order to give the tenon a deep bearing at the root, without greatly increasing the size of the mortise. Making the

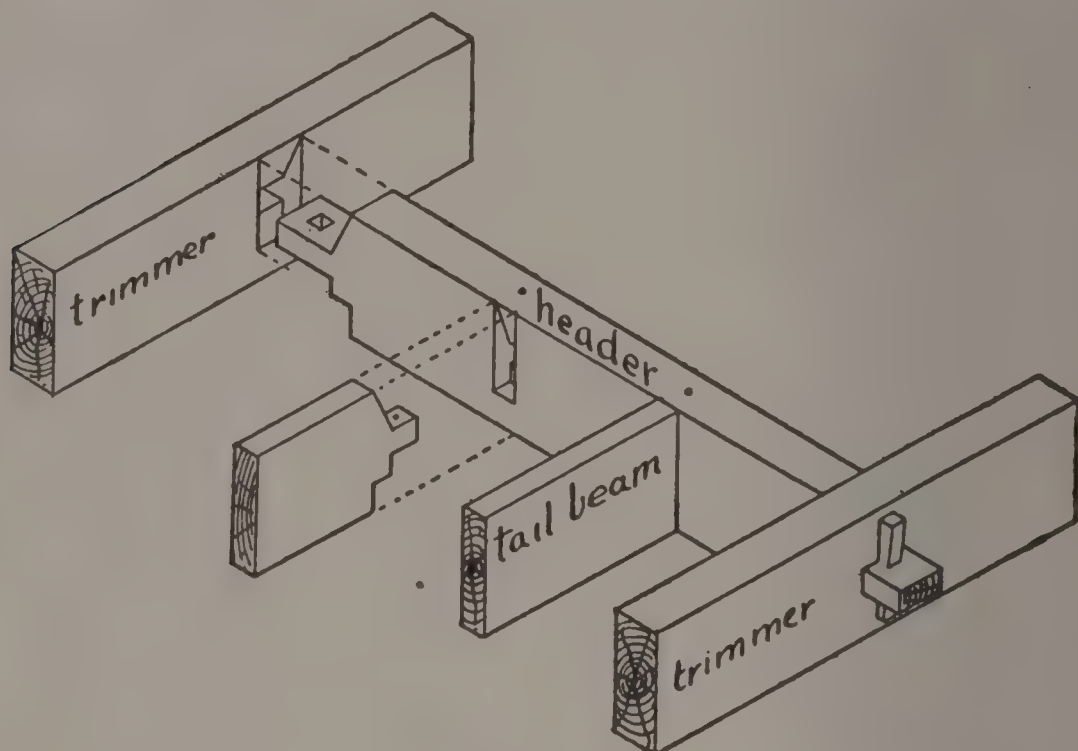


Fig. 258.

mortise unduly large would, of course, weaken the girder. The desired deep bearing is secured by

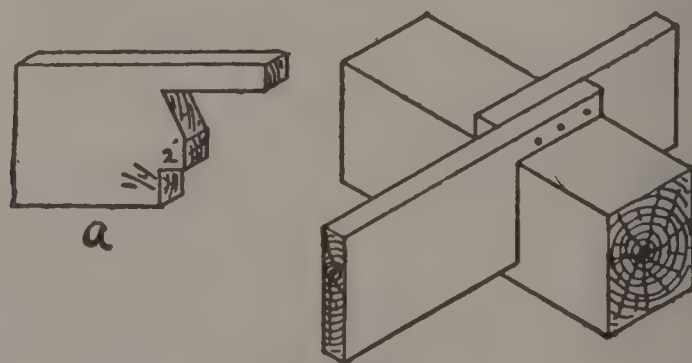


Fig. 259.

adding below the tenon a tusk having a shoulder which in trimmer work penetrates to a depth about one-sixth the thickness of the joist. Above the

tenon is formed what is called a "horn," the lower end of which penetrates to the same extent as the tusk. By this arrangement the strength of the tenon is greatly increased as compared with the common form, while the mortise is not made very much larger. In order to hold the parts together the tenon is projected through the girder and pinned on the outside as shown in the sketches.

So much for a description of the tusk-tenon, as it is theoretically, and as illustrated in Fig. 261. Many times, however, the tusk-tenon is attempted upon the lines shown in Fig. 260. For example, if the beams are 10 inches deep, it is placed so as to leave 6 in. beneath. This does not secure the maximum of strength. The tenon is made square on the shoulder, which is not the best that might be done and has below the root the bearing indicated by A in the sketch.

The object in view with this joint, where applied to small timbers, as, for example, headers in floor beams, as well as in heavy framing, is to secure a perfect bearing at all points. In the application of it to floor beams the special object is to weaken the trimmer as little as possible.

It is scarcely necessary to remind the readers that a beam weighed and supported like a trimmer has the fibers on the bottom in tension, while those at the top are in compression. If this is conceded, then it becomes evident that whatever is to be cut out of the beam ought to be cut out as near the

center as possible. The root of the tenon should pierce the beam at a point as nearly on the neutral axis as may be. The nearer it is placed to the bottom of the beam, that is to be connected with the trimmer, the less likely the tenon is to split off, and as near the middle of the beam from top to bottom as possible, is the proper point for the tenon. There is some liability of the tenon splitting off, however, wherever it is placed, and it is

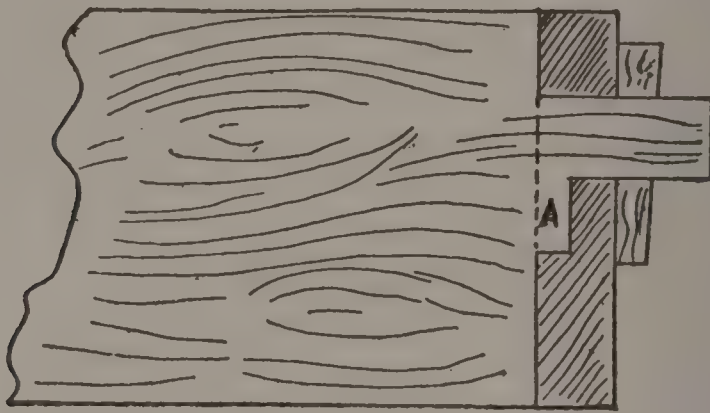


Fig. 260.

for this reason that the shoulder D, as shown in Fig. 261, is introduced. The bearing E also helps to strengthen the construction.

Fig. 260 is not an ideal tenon, so in practice it is always better to employ tenon shown at 261.

One very important feature in heavy framing is the construction of wood centers for turning over brick or stone arches, and I purpose giving at this point some examples of centers most in common

use, and a few suitable for bridge and other large works.

Before describing the types of center in common use it will be well to consider the points that must be observed in their construction. The principles that are enunciated below apply to most temporary structures, but are here intended to apply chiefly to centering. (1) Absolute rigidity of the struc-

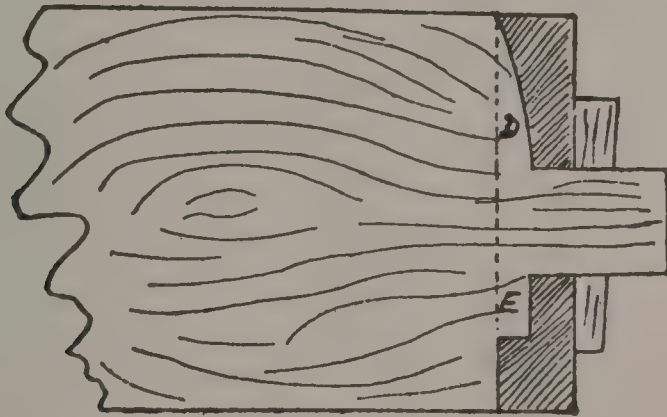


Fig. 261.

ture is required. (2) A wide margin of safety in the resistance of the material and fastenings of joints. (3) Fastenings should be easy of application and removal, and yet perfectly reliable. (4) The structure must be economically designed, which does not mean always to use as little material as possible, but rather that it shall sustain the minimum amount of damage in jointing and framing, so as to allow of re-use for similar purposes when the sizes are suitable, or conversion into timber for other purposes. (5) Joints must be so

arranged as to transmit stresses directly with the least possible tendency to slide when under compression, and where necessary the fastenings of the joints must be such as to allow of the stresses being severed without movement of such joints during the loading of the center. Thus, when an arch is being erected, if of a semi-circular or semi-elliptical outline, the first few stones or bricks will produce no stress in the center, for the tendency of the blocks to slide is resisted by the friction between the surfaces until the angle of repose of the material is reached. After passing this point, the center becomes quickly loaded and the compression at the haunches is severe, and being loaded symmetrically from the two sides, produces a strong tendency to lift at the crown, which the center has to resist. What is required is an arrangement of trussing the ribs, or separate vertical frames supporting the lagging, that will resist this deformation, and further, that of the continued loading up to the insertion of the key block. To attain resistance and rigidity so as to overcome these difficulties requires careful consideration in large centers. The center as a whole consists of the supports, the curved trussed ribs, and the cover or lagging which the ribs support.

First, as regards the ribs, these should be trussed frames of the required outline placed at 3, 4 or 5 feet centers, according to the weight of the arch, strength of lagging and timbers; each

rib or bent receiving direct support. The construction of the rib may be accomplished in one of three ways: (a) It may have the curve built up in two or more thicknesses; (b) it may be of solid material, connecting the struts, its outer surface cut to the curve; or (c) the frame may be trussed to the outline very approximately, and the curve formed by shaped packings nailed to the other members. The general practice appears to be to use (a) in two thicknesses, for small centers, simply nailing or screwing the sections together; (b) for large civil engineering structures; and (c) also for the latter work and for arches of moderate span that are near the semicircular outline. We may consider (c) as a modification of (b). But there is a great advantage in using the built-up curve for centers of comparatively large size, especially where the whole rib can be built up and then raised into position, because of the fact that if the joints between the lengths of material are radial (normal) to the curve, the rib, apart from trussing, is in a great measure self-sustaining, its form being that of an arch, and, therefore, capable of sustaining a load. The writer knows of some cases where built-up curved ribs (without trussing), merely lagged and braced, have been successfully used to build segmental arches of small rise over moderate spans. This advantage of the built-up rib is increased if three thicknesses of material are used, and $1\frac{1}{2}$ in. bolts instead of spikes

employed at the joints. Moreover, the ribs are then very easily taken to pieces, the bolts used again for any suitable purpose, and the lengths of curve either re-cut for similar purposes or converted to other uses.

The following rules and definitions regarding centers and centering will be found quite useful to the workman and are inserted here for his guidance and consideration:

“Centers are temporary wooden structures upon which arches are built.

For convenience of reference they may be classified according to construction, as turning pieces, rib centers, laminated, or “built up,” framed and trussed, close-lagged, and sundry special varieties designated in connection with the purpose for which they are used, such as dome, circle on circle, groin, and sheeting centers.

Centers being required purely for temporary purposes should be designed so as to injure the material as little as possible, with a view to its subsequent use for other purposes.

This condition often necessitates the employment of larger timbers than are actually required to meet the stresses occasioned by the load.

But it is a good fault in centering to have the timber “too heavy,” as in extensive works such as railway arches or large vaults, stresses sometimes develop in unexpected directions.

Every effort should be made to transmit the

load to the ground, directly, by vertical supports; and if the distance is great these should be braced.

Inclined supports, as sometimes used, to give clear way for traffic, are apt to shrink and become loose, riding on the dogs, and so throw themselves out of bearing if not watched.

The above does not apply to arches whose abutments are piers. In this case it is better to throw the weight of the centering upon the footings, or some part of the pier, otherwise when the center is struck, and the extra weight of the arches thrown on them, they may settle unequally.

They must be constructed in such manner that their shape will not be altered by the stresses induced by the load, which, of course, are continually altering in amount and direction as the work proceeds. This requirement is best met by bracing and counter-bracing.

It is inadvisable, except in the case of very heavy centers, to employ mortise and tenon joints in the construction, as, apart from the expense of these, it is requisite, in order to obtain good results, that the timbers should be "true," and as this condition is not essential for any other purpose in the construction, it is unwise to so design it when other and simpler joints will answer the purpose equally well.

Large centers should be so constructed that they may be readily set up, and it is better to build them on the site, piece by piece, having previously

fitted and marked them, than to build them complete on the ground, and sling them into position with a crane. This slinging will often disarrange the braces and distort the ribs. This refers to "Builders' Centers" only. Engineers centers, usually more elaborately braced and tied with iron rods, being not affected thereby.

Centers should also be capable of easy striking and ready readjustment. These requirements are usually met by introducing pairs of folding wedges between the supports and the lower bearings of the center. There is always a danger of these wedges, whilst being driven back, suddenly shooting away and leaving the center unsupported. This may be avoided by using three wedges, as shown at Fig. 286. Then if either the top or bottom one is driven out, a pair still remain to take the bearing, and "set up" again if required. An elaboration of this method is shown in Fig. 287, a continuous wedge, used sometimes for heavy centers. It is impossible for this form to slip, and it can be locked in position when set up by a key driven in one of the slots.

Screw jacks may also be employed to obtain regular easing in doubtful cases of vaulting or restorative work.

Another point to remember in designing centers, is that there may be projections below the springing, such as cap or neck moldings, that will prevent the lowering of the center if due allow-

ance is not made for them; an example of this is given in Figs. 268 and 277. The tie-piece should be made a little shorter than the clear distance between the projections, and raised above the springing to a point where it will cut the intrados of the arch.

The tail-pieces, completing the center down to the springing, are made up separately and inserted after the body is set up. These tail-pieces would not be required for a masonry arch, as the haunch voussoirs do not take a bearing on the center until their bed joints exceed an angle of 32 degrees with the horizontal. This is due to the friction of the stone on its bed preventing its sliding, unless the angle of the bed is in excess of that mentioned.

It may also be noted that the whole weight of any arch stone is not taken by the centering until the stone is in such a position on it that a vertical line drawn through its center of gravity would pass on the outside of its bed.

It follows that during the construction of the arch, the load gradually increases from the springing to the crown; and that in a semi-circular arch, when about half way up between springing and crown, the load will have a tendency to force the haunches in and spring the crown up. This demonstrates the necessity (a) of making the center stronger in the middle than at the haunches, as a greater weight will have to be carried by that part; and (b) either that the stress from the haunches

be taken direct to the ground by supports at the feet of the braces, as in Figs. 271 and 277, or where no support is available from below, at the middle of the span by framing the feet of the haunch-braces into the foot of a king post, which will counteract the tendency of the latter to rise, and then to meet the stress at the crown that will come later by taking braces from the head of the king post to the end of the tie-piece, directing the stress to the supports at the springing as shown in Fig. 272.

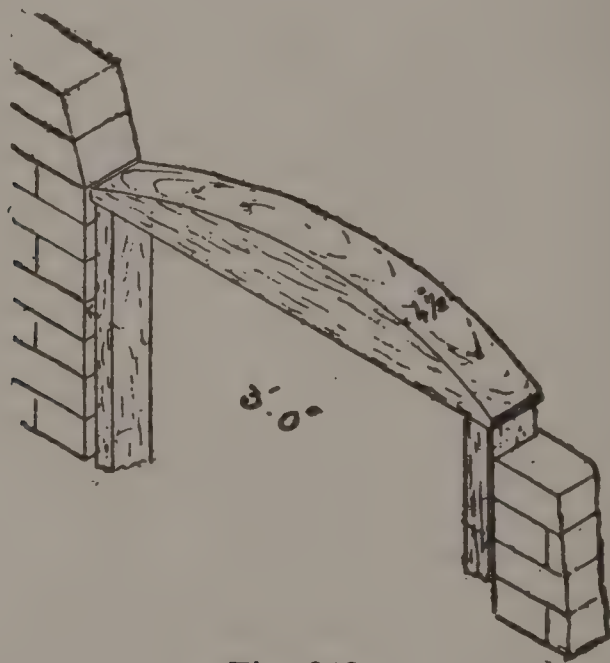


Fig. 262.

It is safer to increase the number of ribs than the thickness of the lagging. It is difficult to lay down any rule for the spacing of the ribs, as the conditions vary in almost every case, but they must be close enough to prevent any individual lag

yielding under the load, and so crippling the surface of the arch.

It must be remembered that the bricklayer requires to pass his plumb rule and lines across the face of the work, and over the openings, so that the ends of the lagging should be kept within the line of the finished work.

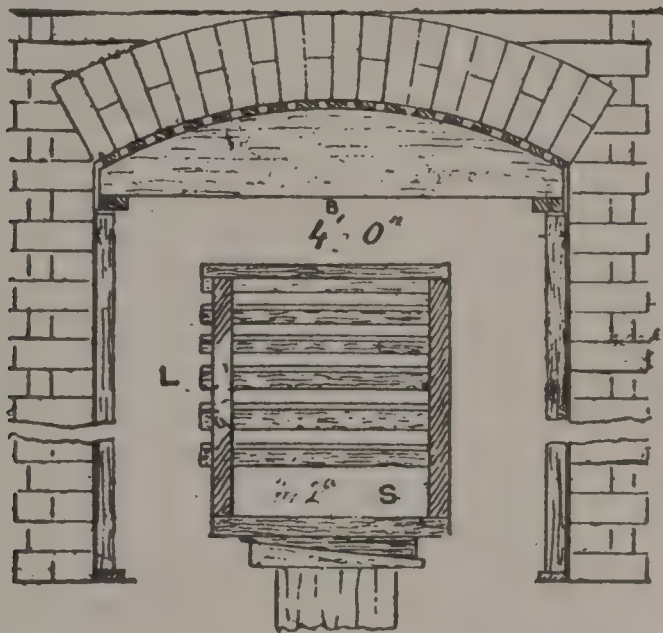


Fig. 263.

It is a convenience to let the lags run over the ribs about $1\frac{1}{2}$ in., so that they can be trimmed as required.

Lagging for brickwork should be spaced not more than $1\frac{1}{2}$ in. apart. For masonry they can be spaced according to the length of the voussoirs used. A bearing at each edge is sufficient. Frequently where the voussoirs exceed two feet in length, lagging is dispensed with altogether, the

stones being supported by blocks or wedges arranged as the work proceeds. This method is shown in Fig. 277.

Oak is often used for wedges, but maple is a better wood, being much less likely to split; it is also naturally smooth and slips well. If oak is used, its surface should be soaped or black-leaded. The wood should be dry, and if machine cut, a fine tooth saw should be used, or if cut with a coarse saw, the faces should be planed. The thin end should not be less than $\frac{3}{8}$ in. thick, and the corners of both ends "dubbed" off, as shown in Fig. 286, to prevent splitting.

Wedges should be driven parallel to the abutments, i. e., across the ribs and have a block nailed behind them to prevent running back.

The turning piece, Fig. 262, is cut out of a piece 2 in. by 4 in.; it is used for the outside arches of door and window openings, of slight rise, and half a brick thick. For thicker walls the rib center, Fig. 263, is used. This is formed by shaping two boards, about 1 in. thick, to the curve, keeping them at a proper distance apart by stretchers, S, nailed on their lower edges, and covering the curved edges with lagging pieces, L, about $1\frac{1}{2}$ in. by $\frac{3}{4}$ in., at intervals of $\frac{3}{4}$ in. for ordinary work.

When the rise of a center is small in comparison to its span, it is inconvenient to describe its curve with a radius rod, and the method shown in Fig. 264 may be adopted. Take a piece of board of con-

venient size and draw a line across it from edge to edge, equal in length to the span of the arch required; at the center of this line draw a perpendicular equal in length to the rise, draw a line from this point, b, to the springing point, a, and cut the ends off beyond the line; the portion cut off is shown by dotted lines in the sketch. Two nails are driven into the piece from which the segment is to be cut, at a distance apart equal to the span, as at a-c, and the templet placed in the position shown in Fig. 264, with a pencil held at point b; if the

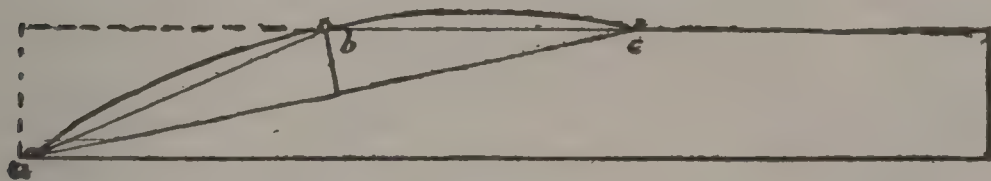


Fig. 264.

board is now moved around towards a, keeping it pressed against the nails, one-half the curve will be described, and on turning over and repeating the process the other half may be completed.

An alternative method is shown in Fig. 264, suitable for very flat arches. Lay off the rise, and span, perpendicular to each other, as a, b and c, upon any convenient surface; draw the cord line a c, lay the board from which the templet is to be cut in a suitable position over these lines, and reproduce the line a c upon it; also draw the line e d parallel to a b; next cut the board to this triangu-

lar shape, as shown by the shaded portion; then if nails are driven in the board to be cut at points a and c, and the templet moved around against them, the curve will be described by a pencil held at point e, as shown by the dotted line.

When the rise is more than the width of a board will accommodate, a variation of this method may be used. Into the board or boards from which the rib is to be cut three nails are driven, as at a, b, c, Fig. 265, arranged so that a-c shall equal the span and b the rise, then place two strips of wood against the nails as shown, crossing at the crown, and fix them together; a third piece nailed across to form a triangle will keep them in position, if the nail at the apex is withdrawn and a pencil substituted; when the triangle is moved around as before described, the curve will be produced. One of the legs of the triangle should be twice the length from a to b.

A built-up center is shown in Figs. 266 and 267; the ribs in this variety are formed in two thicknesses, the laminae being nailed together in short lengths, the abutting joints of each layer meeting in the center of the other. These abutment joints should not be less than 4 in. long, and should radiate from the center of the curve. The length of the segments is determined by the amount of the curve that can be cut out of a 9 in. board. The two longer layers of the rib at the springing are cut off at the top edge of the tie-pieces, and form with the

upper layer, which runs down to its bottom edge, a rebate, in which the tie rests. The layer running down is nailed to the tie. The tie-piece may be

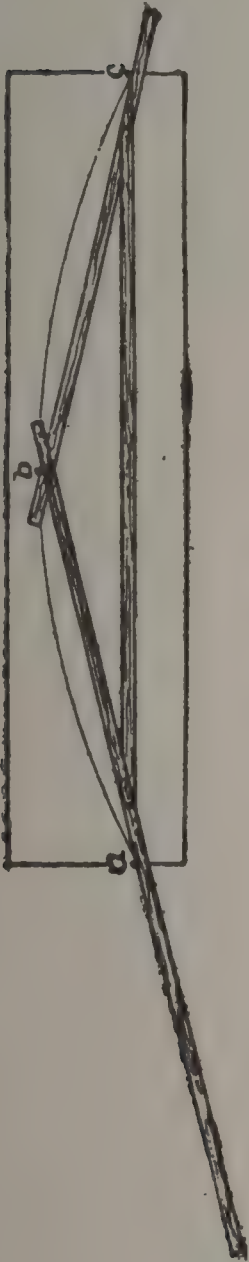


Fig. 265.



Fig. 267.

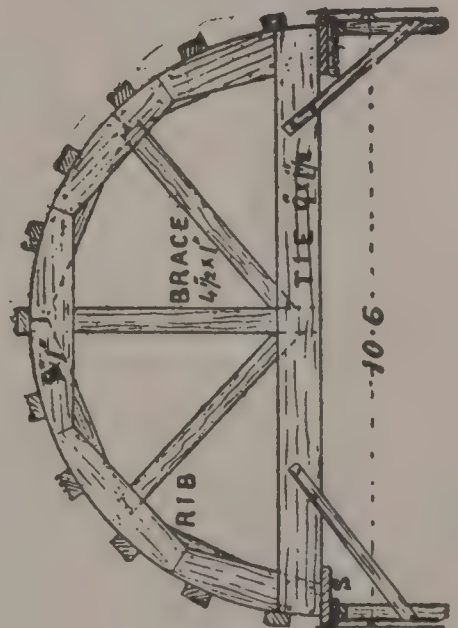


Fig. 266.

from 1 in. by 7 in. to 1½ in. by 9 in., according to the span. The braces, of similar scantling, should radiate from the center, and be shouldered slightly upon the same side of the tie-piece that the ribs

run over; their upper ends are nailed on the side of the layer of the rib, and take a bearing under

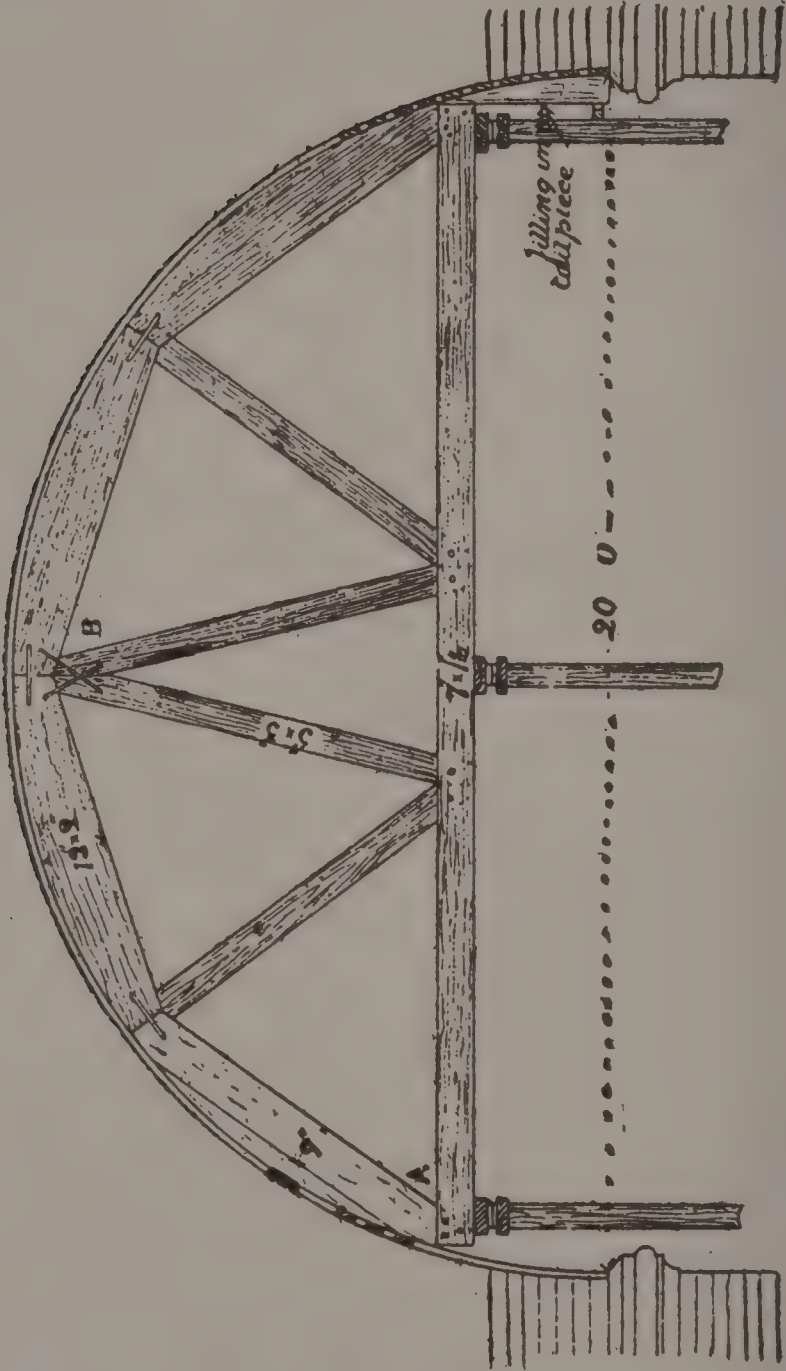


Fig. 268.

the edges of the other. This form of center may be safely used for spans up to 12 ft., but although sometimes used for greater, they are not to be

recommended owing to the numerous joints, and the possibility of splitting the segments in nailing.

The framed center, Fig. 268, is better adapted for spans between 12 ft. and 20 ft. The ribs are solid, out of 2 in. or 3 in. by 9 in., as the span is less or more, and if this is not wide enough to get

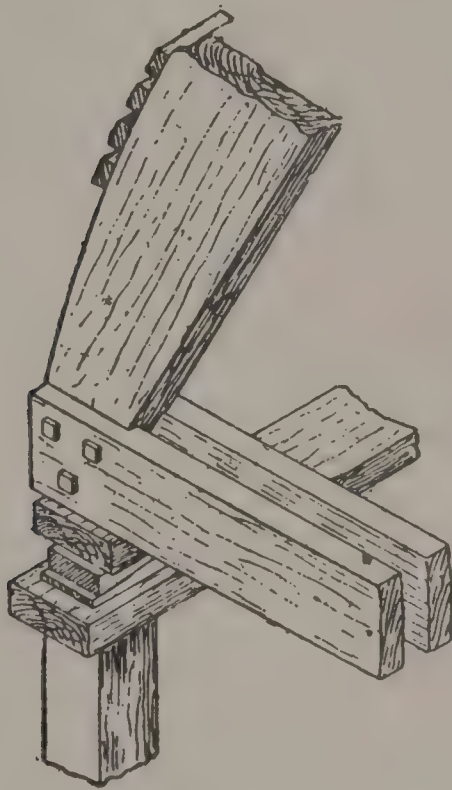


Fig. 269.

the curve out, in four or five lengths, must be made up to the required width, with similar pieces spiked on the back. The ends near the springing are shouldered out $1\frac{1}{2}$ in. on each side to sit on the tie-pieces, which are in pairs; the upper ends have slot mortises cut in them to receive the tenons on the braces (see Figs. 269 and 270). The lower

ends of the braces are shouldered in a manner similar to the ribs. The ends in the ties are fixed with coach screws, the upper ends by dogs.

A trussed center of economical construction is shown in Fig. 271, consisting of a triangulated frame of quartering, used as a support to the ribs. The foundation frame may take the form of either a king or queen post truss, as the span and number of braces required may indicate; but whatever the form, as previously mentioned, the stresses should be directed to the points of support, in this case three.

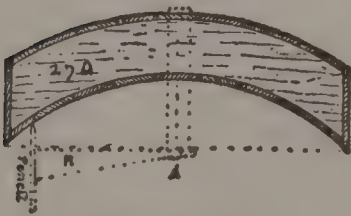


Fig. 270.



Fig. 271.



Fig. 272.

The joints are formed by notching the ends of the braces into the ties, and keeping them in position by means of dogs. No tenons are used, as from the construction all the members will be in compression; short puncheons should be used under the joints of the ribs, as shown at PP. This form may be used safely for brick arches up to 25 ft. span, but must be supported in the middle. When this course is not possible a trussed and framed center, similar to Fig. 272, may be employed. This is a very strong construction, espe-

cially suitable for masonry arches in which considerable cross strains, due to the slower manipulation of the load, have to be met. Here it will be seen that the haunch loads are directed to the foot of the king post, and not to the tie; from that point it is directed by-way of the struts D to the supports at the end of the tie. These same struts, D, also take the crown load. The king post, tie piece and struts D are all made solid, the latter



Fig. 273.



Fig. 274.



Fig. 275.



Fig. 276.

passing between the struts E, into which they are notched slightly, to stiffen them (see detail, Fig. 275). Packing pieces are used at the upper ends of the struts E, to bring the ribs up to the bearing (see Fig. 276), the whole fastened together with spikes or coach screws. The ends of the ribs at crown and springing are sunk in about $\frac{3}{4}$ in. (see Fig. 274), the lower ends being spiked through the back. The lags are 2 in. by 3 in., spaced ac-

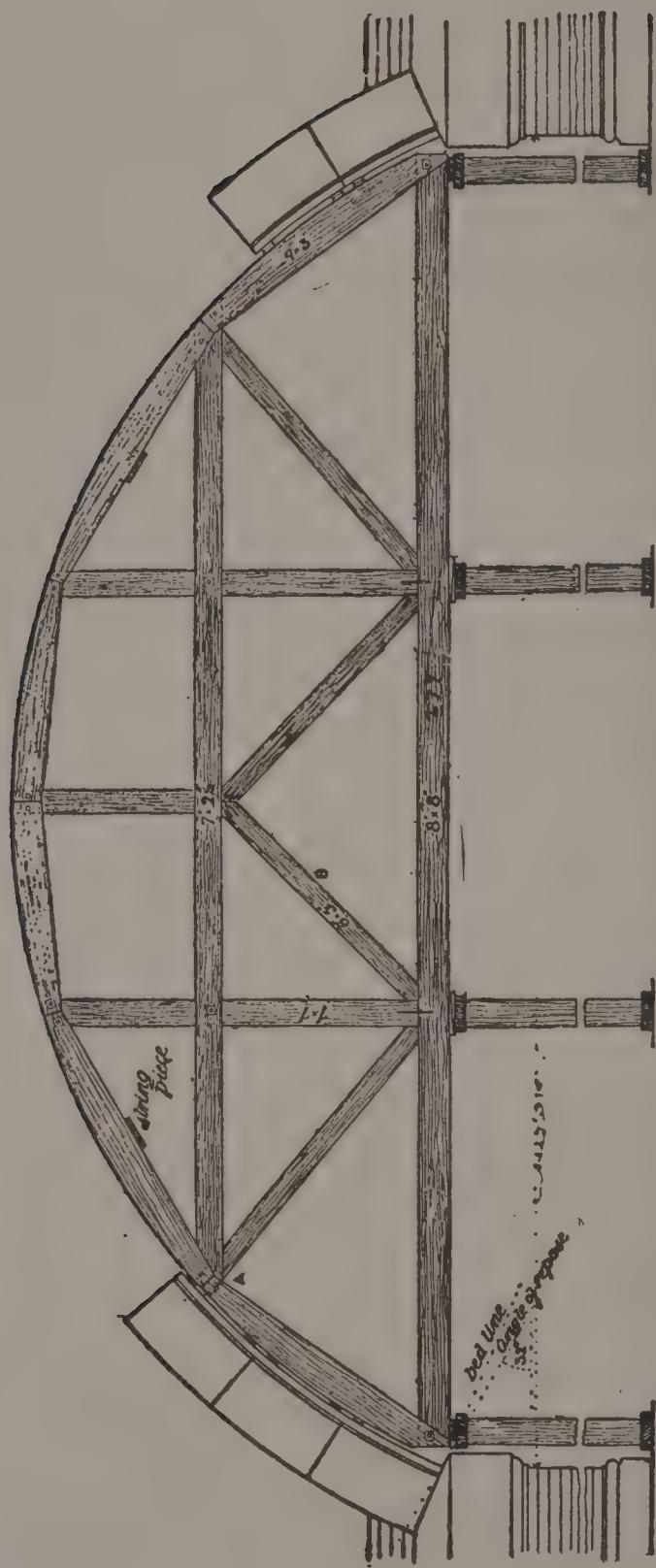


Fig. 277.

cording to requirements, about two-thirds of the length of the stone from the bed joint of each voussoir will be found the best position. The ribs are spaced at 3 ft. 6 in. apart. The lags in the example are shown notched into the backs of the ribs $\frac{1}{2}$ in.; this method is often adopted when the center is built in situ, and the length of the arch is such as to require several ribs. The two end ribs should have a radius rod fixed on the tie-piece, to be swept round the circumference, and the lags can be brought into the line of curve by adjusting the depth of notch. When the end pair are correct, a line sprung through, or a straight edge applied, will give the depth of the intermediate notching.

A trussed center for a large span is illustrated by Figs. 277 and 283. Figs. 283 and 284 are details of the construction.

Centers of the above description are generally constructed as follows: a chalk line diagram, complete, and full size, is laid down on a suitable platform or floor, the timber from which the segments of the ribs are to be cut are laid in position over the curve alternately, and the joints marked with a straight edge, radiating from the center; or, in the case of elliptic or parabolic arches, drawn normal to the curve at the points where the joints occur (see n, Fig. 282). When the joints are cut the segments are laid down and nailed together, a radius rod is then swept round

to mark the curve, or in segmental arches the triangle, Fig. 282, may be used; the pieces are then separated and cut, again laid down with spikes driven temporarily around their periphery to keep them in place; the struts and ties are then laid over them in position, and the lines for the shouldering and notching drawn on; each joint should have a chisel mark made on the pieces to identify them, and the joints being made, the whole can be fitted together, nailed up and bolted, then taken to pieces ready for re-erection in situ.

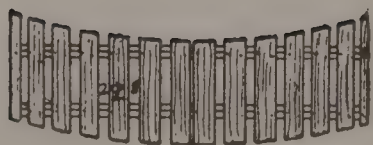


Fig. 278.



Fig. 279.

Close lagged centers for various purposes are shown in Figs. 278 and 280 and 284. The surface of these is required to be finished more accurately than in the ordinary center, because the brick-layer sets out the plans of his courses thereon, and thus obtains the shape of the voussoirs. The lagging is nailed closely round the ribs, and brought into the curve afterwards, with the plane.

The profile line being obtained either by radius rod or templet. In the case of Dome or Niche

centers, a reverse templet affords the readiest guide for shaping the surface.

A circle on circle center, when semi-circular in elevation, may be constructed as shown in Figs. 274 to 278. Two ribs are cut to the plan curve, and upon each edge of these narrow vertical laggings, rather closely spaced, and thin enough to bend easily to the curve, are nailed. The bottom rib is placed at the springing, the other about half way between it and the crown, when

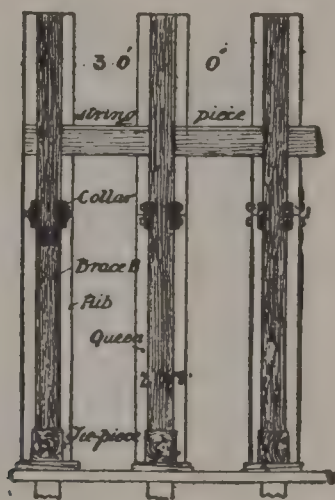


Fig. 280.

this side lagging is fixed, a radius rod shaped as in Fig. 277, and set out so that the distance between the pivot A and the middle of the V notch is equal to the radius of the required arch, less the thickness of the soffit lagging; is mounted on a temporary stretcher, C, at the middle of the springing; this is swept round the lagging on each side, a pencil being held loosely in the V notch, thus obtaining the outline of the elevation

curve. (Of course if the soffit were splayed the inner radius would be shorter, but struck from the same level as the outer.) The boards are cut square through to the lines and the cross lagging nailed to their ends, as shown in the section.

When the plan curve is flat, such as would occur in a narrow opening in a large circular wall, the vertical lagging may be omitted and the center built as shown in Figs. 278 and 282, plain vertical ribs being employed, and the lags allowed to overhang sufficiently to form the plan curves. They require to be rather stouter than usual to ensure stiffness.

There are two ways in which centering for intersecting vaults may be constructed: first, when the vault is not of great span, a "barrel" or continuous center is made for the main vault, long enough to run about two feet beyond each side of the intersecting vault. The centers of the smaller vaults are then made with the lagging overhanging the rib at one end, the two centers are then placed on a level surface and brought together in their correct relative positions, and the loose ends of lagging scribed to fit the contour of the main center, and then nailed thereto.

This method, however, is unsuitable for vaults of large span, as the lagging would be liable to sink at the intersection through the absence of support. The second method, shown in Figs. 281 and 283, is then adopted; a rectangular frame is

first constructed equal in length to the proposed center, and in width to the clear span between the walls; this frame is halved together at the angles, as shown at E, Fig. 283, and forms a firm base for fixing the ribs to; a similar frame is made and fixed underneath for the cross vault, and ribs of the requisite curvature are set up at the four ends, also at the intersecting line or groin, being secured firmly at the base.

Fig. 281.

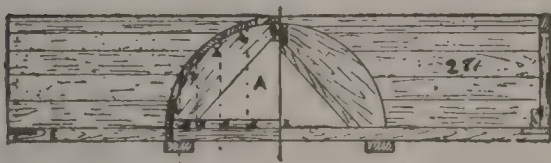


Fig. 281.

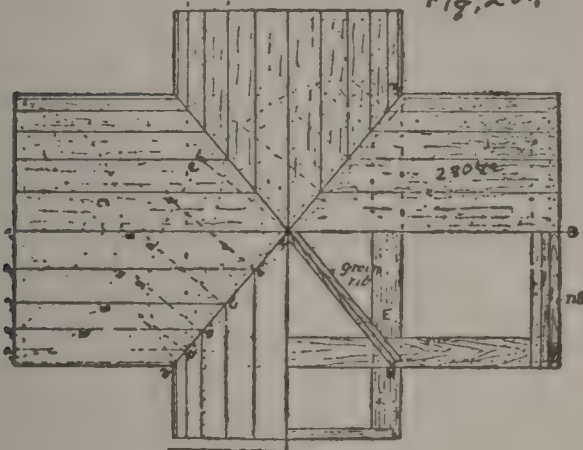


Fig. 283.

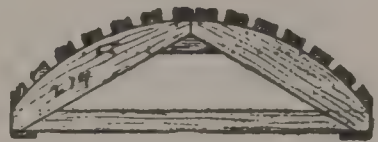


Fig. 282.

The groin ribs are made in two thicknesses for convenience of beveling, the angle of the seating being a re-entrant one.

The method of producing the bevel is explained elsewhere. The lagging of the cylindric center should be fixed first and worked off true with the

aid of a plane and straight-edge; a thin straight lath should then be bent round over the center of the groin rib, and a pencil line drawn down its edge; the ends of the lagging being trimmed off to it with a chisel held plumb; this will give the proper intersection for the main lags, and when these latter are cut to fit their true outline at the intersection may be obtained by marking on their ends with a pencil drawn down the surface of the cylinder. A templet, obtained as described below, applied at the ends will give the profile at the extremities, and each lag can be placed to fit before nailing on.

To find the space of a groin rib when the shape of penetrating vault is given: First, by means of ordinates; divide the semi-circular rib, A, Fig. 283, into a number of parts, as at 1, 2, 3, 4, 5; draw perpendiculars from these to the springing line x, and produce the lines to cut the plan of the center of groin rib, in a, b, c, d, x; erect perpendiculars at these points to the plan line, d-f, and mark off on them heights to correspond with the similarly marked heights in the section, Fig. 283; these will give points in the curve, which may be drawn by driving in nails at the points and bending a thin lath round them. The curve may, however, be drawn quicker by a trammel, taking the height, x-, for the minor axis, and the length, d-x, for the major axis. When a properly constructed trammel is not at hand, its principle may be utilized in the

following manner: To draw an ellipse without a trammel—Let A, C, B, Fig. 284, represent a board upon which it is desired to draw a semi-ellipse, joint the edge, A, B, straight, draw a line in the center, square with the edge, as C, produce it across another piece of board resting against the first, to D; then mark off, on a straight lath from one end, the semi-major and semi-minor axes; in other words, the rise and half-span of the arch. Keeping these two points upon the lines, A, B, and C, D, arrange the lath in various positions, as shown by dotted lines in Fig. 284, and pencil lines made at its end will give points on the curve.

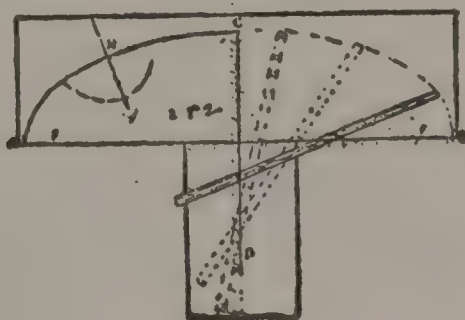


Fig. 284.

To find the shape of the ribs for the main center, Fig. 283, from the points a' , b' , c' , d' , x' , in plan, draw lines parallel to the edge of the center, intersecting the seat of the end rib in points a'' , b'' , c'' , d'' , x'' ; along these lines set off heights equal to the corresponding ordinates in Fig. 281, and draw the outline of the rib through them, as at C, Fig. 284.

To find joint line and direction for braces in elliptic centers, see Fig. 284. First find the focal points, with radius equal to half the span $a b$. Describe an arc from center c , cutting the major axis $a b$ in $f f$; these are the foci. To find the joint line or normal from any point in the curve as n (fixed conveniently for length of stuff), draw straight lines to the foci; bisect the contained angle, as shown by a line drawn through the point n and the center of the constructive arc. This line is a normal or perpendicular to the curve at the point in question, and indicates the direction of joint and braces.

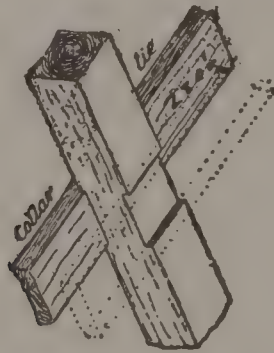


Fig. 285.

The method of bevelling a groin rib for the purpose of obtaining a level seating for the lagging is shown in Fig. 283. Let c, d, b represent the plan of one-half of a groin rib similar to H, x , Fig. 281, and C, d' , the elevation, which may also represent the mould or templet; a, e, f, g is the piece of board from which the rib is to be cut, on the face side of the board draw the full line, C, d' , by aid

of the mould, cut the ends square with each other, as a, e, and d, g, then apply the bevel as found at d in plan from point d' across the bottom edge, square a line across the top end at C, and apply the mould on the other side of the board, as shown by the dotted line with its lower end at the bevel line and its upper end to the level line from point C. If the rib is cut to these two lines, and a similar one made the reverse hand and nailed together, as shown in Fig. 281, its edge will lie in the planes of the directions of the intersecting vaults.

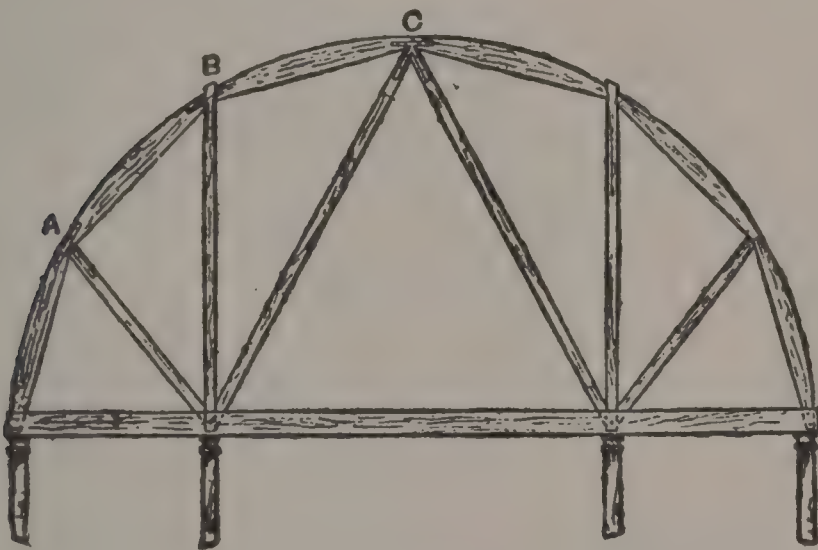


Fig. 289.

The methods shown in the following descriptions and illustrations further affords very convenient means of jointing, for the struts can always be made to meet at points such as A or B in Fig. 289, making possible either a mortise-and-tenon or a bridle joint, without cutting into the rib; for taking either of the two positions given,

the crossing of the sections of the curve provided the necessary entering or receiving portion of the joint, leaving only one-half of the joint to be worked on the strut. In the solid-rib type, the curve is made up of lengths of solid material, with the joints between each part of the strut connections, thereby becoming separate members to the frame. The curve itself has no resistance apart from its connection with the struts. The jointing in this case is more of a permanent nature.

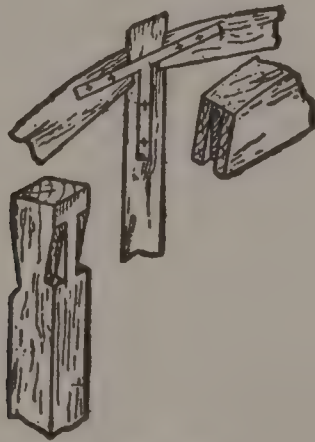


Fig. 290.

The arrangement of the members of the rib, so as to give internal support to the curve, depends on conditions that will be readily noted as the diagrams are perused. If the span and outline be such that the rise is not great, the struts may all be brought directly on to the tie, and concentrated on the intermediate supports, as shown in Fig. 290. This type should have solid ribs jointed at the points A, B, C, etc., as shown (for details

of which see Figs. 290 and 291). If, however, the rise be great, either a flat member must be bolted across the face of the rib so as to shorten the struts effectively, or, better, the type shown in

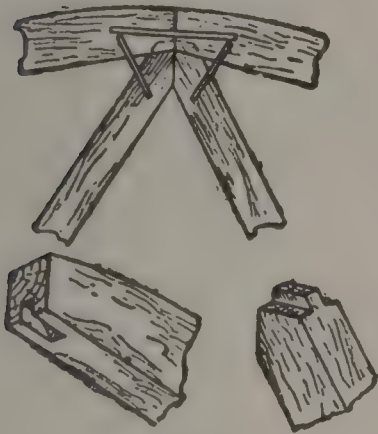


Fig. 291.

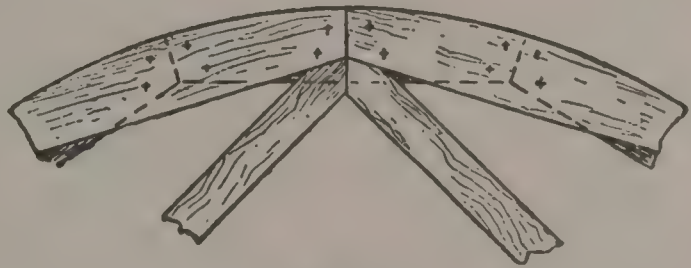


Fig. 292.

Fig. 293 can be adopted, which shows the method of arranging the members more suitably. The struts are much shorter, and can therefore be

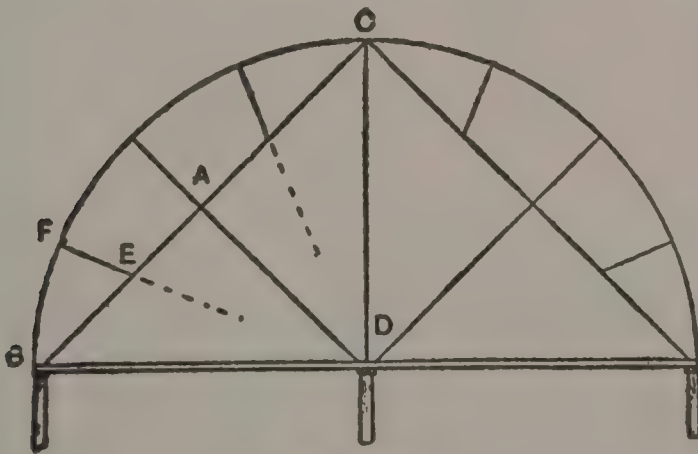


Fig. 293.

lighter. A great resistance to lifting at the crown is obtained, and if necessary the intermediate supports can be dispensed with. Further, the direct supports to the curve may be all normals,

or their equivalent, for this latter condition is satisfied if a pair of struts meet at an equal incli-

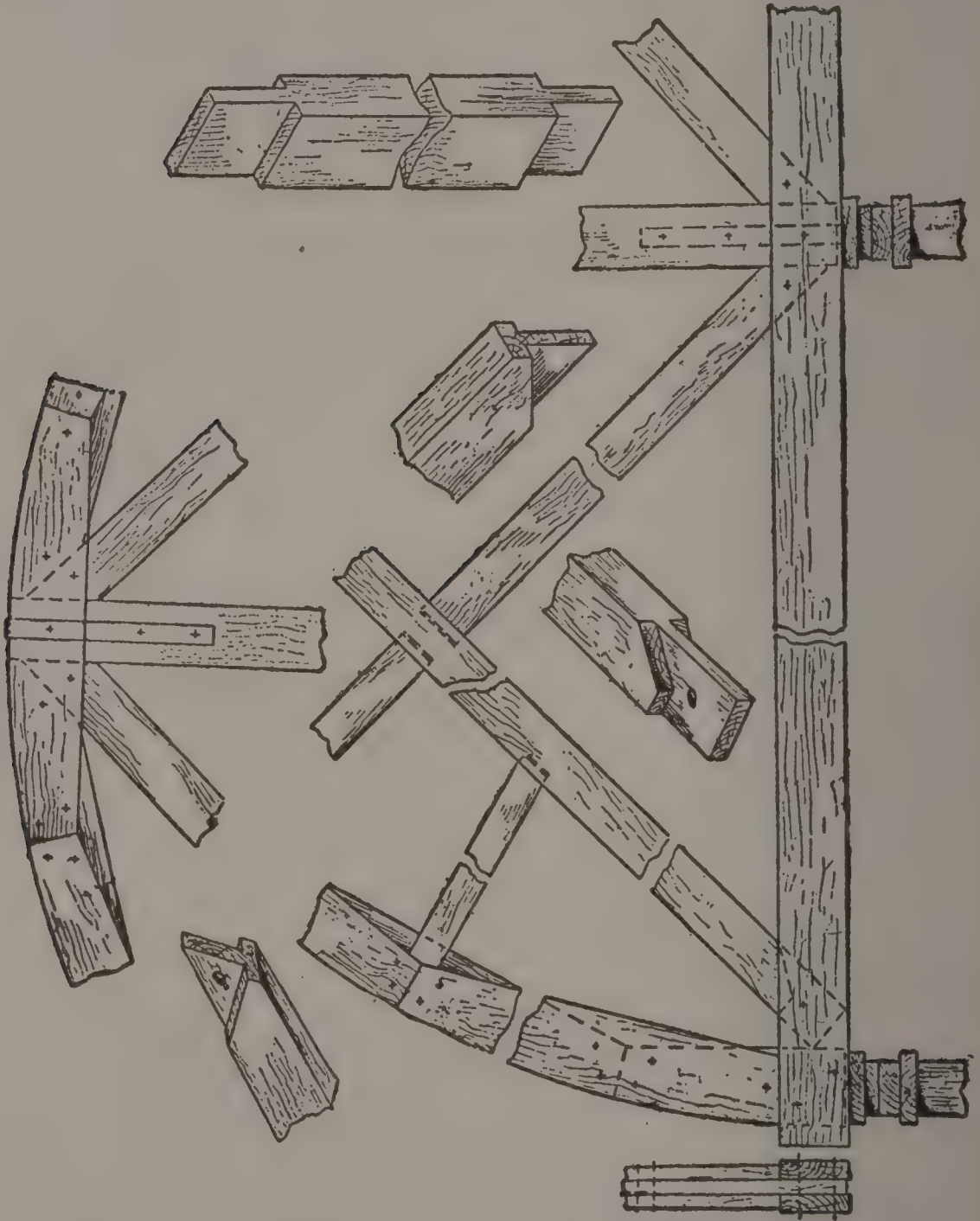


Fig. 294.

nation (Fig. 292). Fig. 293 gives the elevation in line diagram, and Fig. 294 gives the full details of the construction, span 30 ft. The rib is here

built up in three one and a half inches stuff. In both Figs. 289 and 293 the tie is double, of 2x9 in. material. Fig. 293 fulfills the requirement of a good center, and therefore this form may with advantage be generally adopted and modified in the internal trussing as the span increases.

Elliptical arches of long spans are somewhat more difficult to deal with, and I present the following merely to enable workmen to deal with centers of this kind, having a span from 30 to 100 feet.

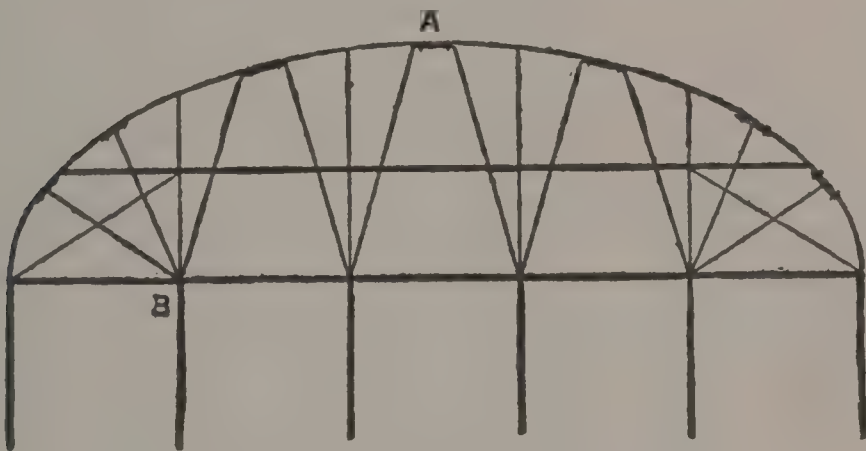


Fig. 295.

Large centers for civil engineering structures, such as bridges crossing rivers in several spans, are scarcely within our scope, these requiring special treatment according to circumstances. But we may with advantage just note on the general forms of centers that are adopted for comparatively flat elliptical arches, together with a modification for a greater rise. Fig. 295 is the general form. It has many points of support, there-

fore little tendency to give at the crown. The whole of the material is of large size, 6 in. by 6 in. being the minimum, and for the platform whole

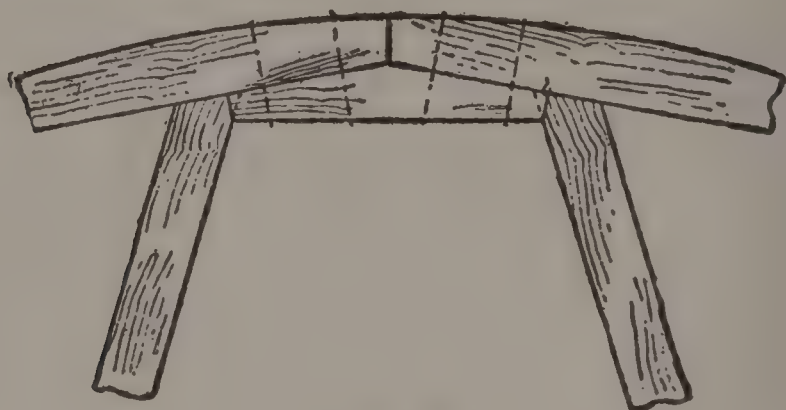


Fig. 296.

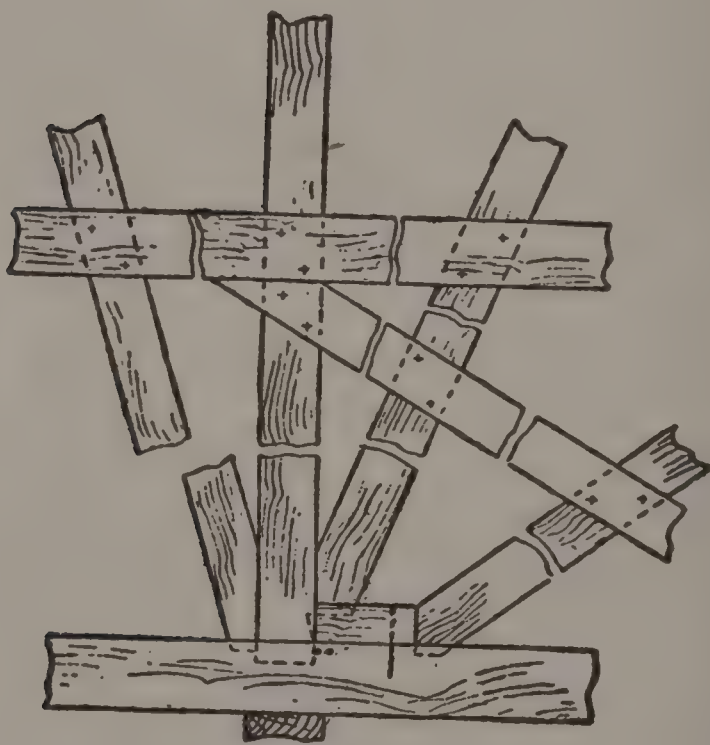


Fig. 297.

timbers 12 in. by 12 in. receive the vertical posts. For heavier work and wider spans, the construction given in Fig. 298 is well adapted. Details in

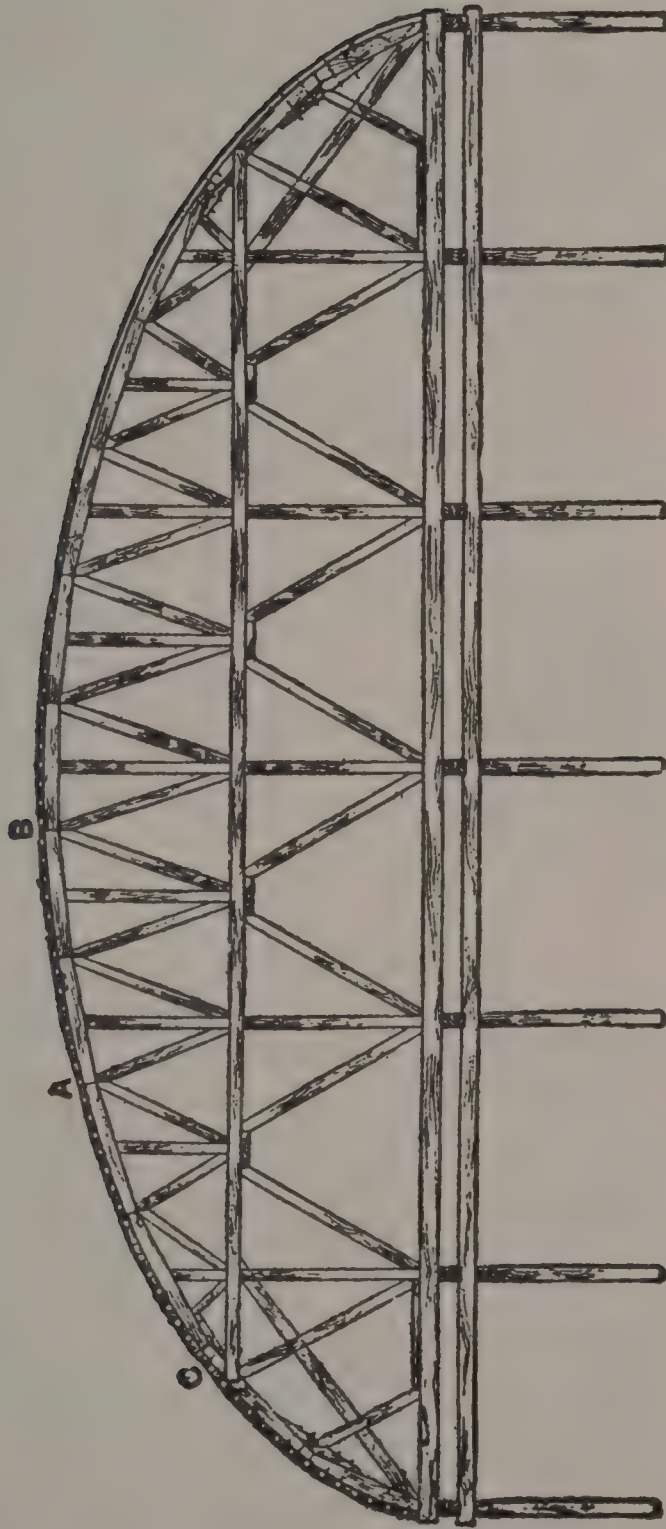


FIG. 298.

Figs. 296 to 300 show the construction of joints which applies throughout. This is built in two tiers, keeping the struts comparatively short, and effectively distributes pressure to the points of support. The secondary horizontal member is large enough to clasp the curved rib at the ends (see Fig. 301), and the whole of the joints are housed or tenoned and strapped where necessary, and as shown in details. Transverse and longitudinal bracing is freely used in the manner pre-



Fig. 299.



Fig. 300.

viously described, and by careful arrangement and sufficient bracing in vertical planes the necessity for strap connections can be reduced to a minimum. For heavy arches such as these the centers are struck by the introduction of lifting jacks or sand boxes, the latter being especially suited to the purpose. They are arranged to contain fine dry sand, with means of escape for the sand as needed, so that the center may be lowered easily and gradually, and to any required amount within the provided limits.

I show at Figs. 302, 303, 304 and 305 four examples of centers in situ, carrying the brick or stone

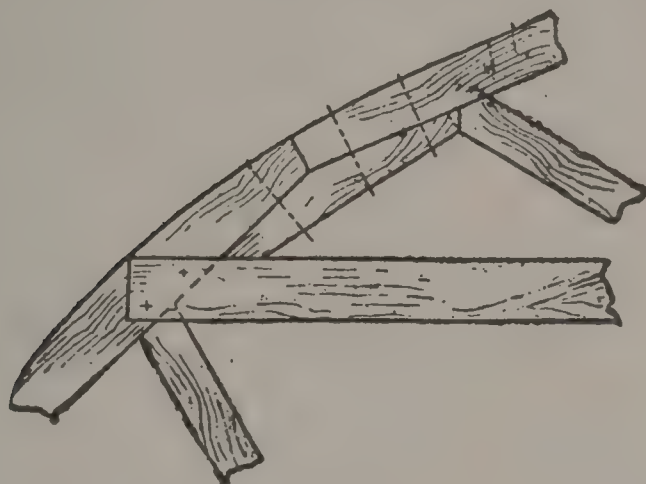


Fig. 301.

work, as the case may be; Fig. 302 shows a center for a small span. It consists of a trussed frame, of which A is the tie, B the principal, or,

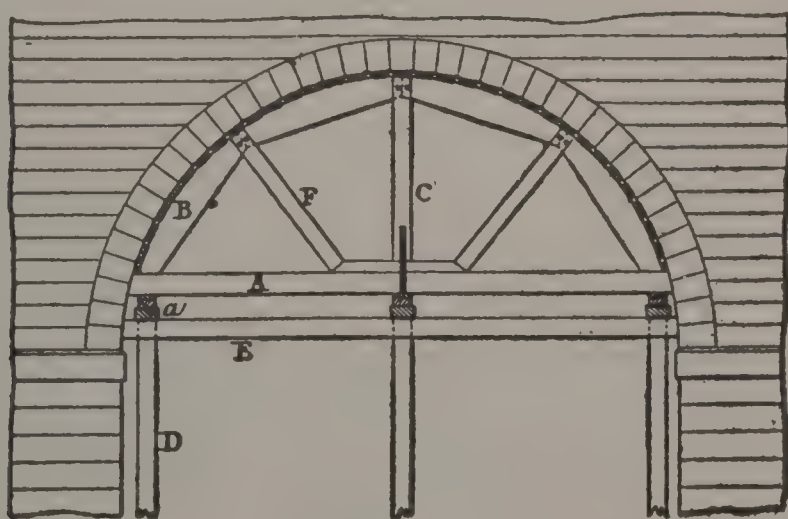


Fig. 302.

as its outer edge is curved to the contour of the arch, it is called the felloë, C the post or puncheon,

and F a strut. The center is carried by the piles D, on the top of which is a capping piece E, extending across the opening; and the wedge blocks are interposed betwixt it and the tie-beam.

Fig. 303 shows center for a small span for an elliptical arch.

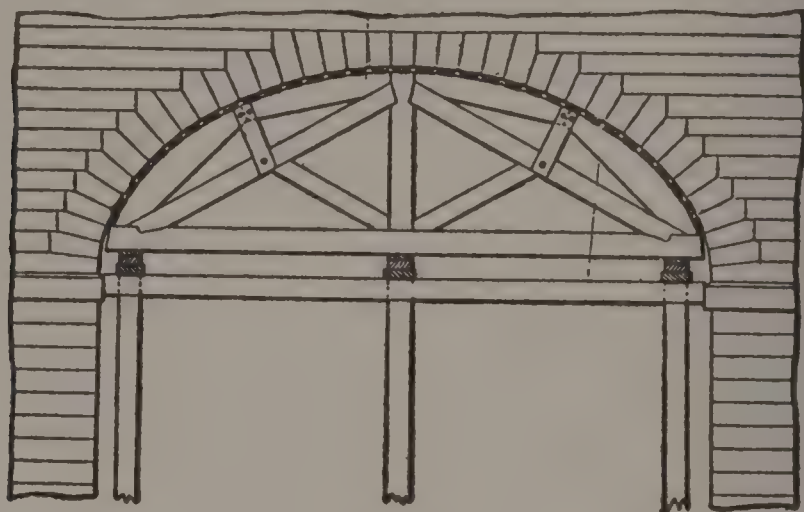


Fig. 303.

Fig. 304 shows a center with intermediate supports and simple framing, consisting of two trusses formed on the puncheons over the intermediate supports as king-posts, and subsidiary trusses for the haunches, with struts from their center parallel to the main struts. This is an excellent design for a center carrying a segmental flat arch having a large span.

Fig. 305 shows a system of supporting a large semi-elliptical center arch rib from the intermediate supports by radiating struts, which, with

modifications to suit the circumstances of the case, have been very extensively adopted in many large works connected with railroads in this country

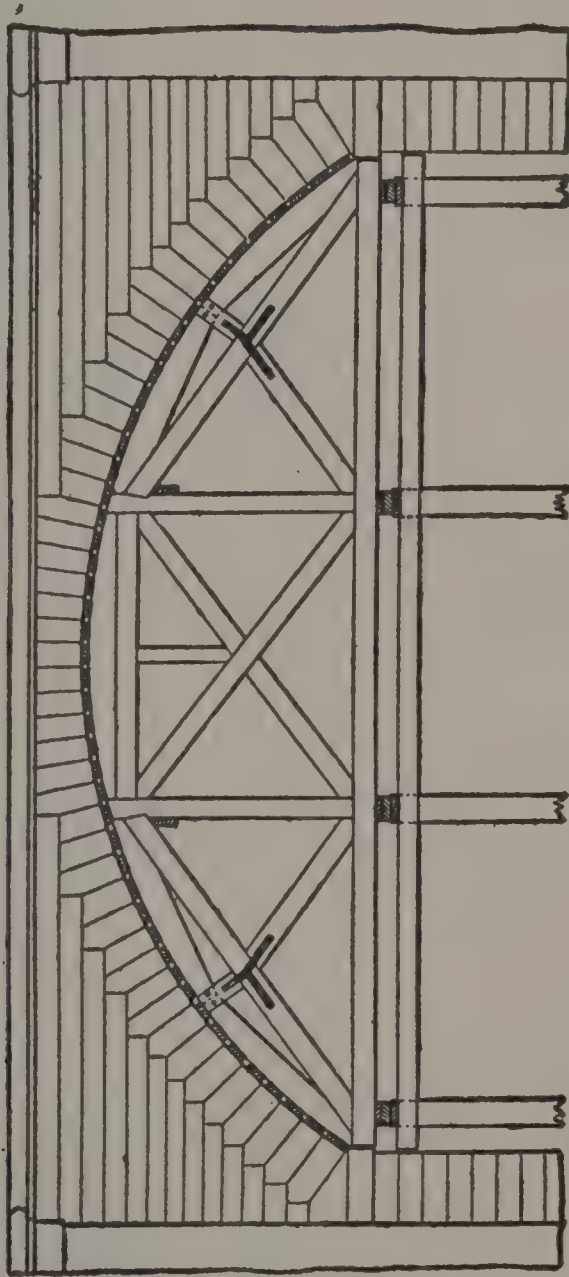


Fig. 304.

and Europe. The struts abut at their upper end on straining pieces, or apron pieces, as they are sometimes called, which are bolted to the rib, and

serve to strengthen it. The ends of the transverse braces are seen at a a.

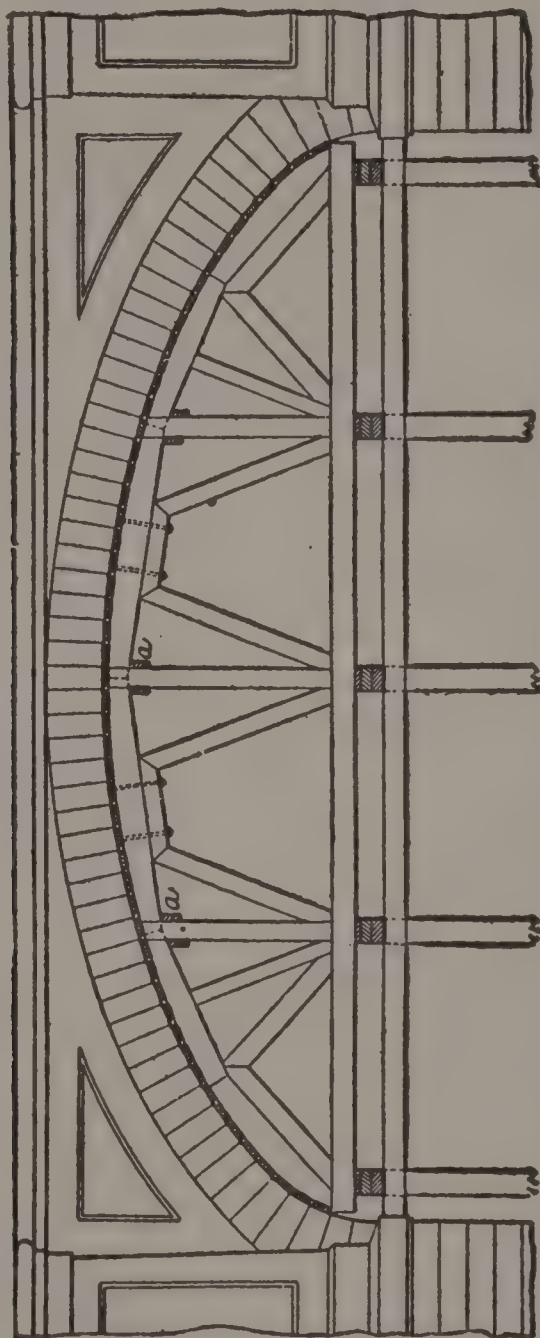


Fig. 305.

The examples and details of centers given in the foregoing are quite sufficient to enable the foreman to lay-out, and execute any job of building a cen-

ter that may confront him; and at this point we leave the subject of centers, and take up another important one, namely, that of timber roof framing. While I propose discussing timber roofs and trusses in general in this department, it is not intended to deal with roof coverings further than may be necessary to make the instructions and suggestions given herewith intelligible and so that they may be understood by every workman who can read.

There are a few general rules governing timber roof framing the workman should always have in mind when building or designing a roof of any kind, a few of which I submit; and which I hope will prove of sufficient importance to be remembered:

1. Every construction should be a little stronger than "strong enough."

2. Roofs should neither be too heavy nor too slight; both extremes should be rigorously avoided.

3. Flat-pitched roofs are not so strong as higher pitched ones.

4. Suitable pitches of roofs for various coverings are: Copper, lead, or zinc, 6 degrees; corrugated iron, 8 degrees; tiles and slates, 33 degrees to 45 degrees.

5. Approximate weight of roofs per square: The timber framing, $5\frac{1}{2}$ cwt.; Countess slates, $6\frac{1}{2}$ cwt.; add for 1 in. pine or hemlock boarding,

2½ cwt.; plain tiles, 14 cwt.; 7 lb. lead, 6 cwt.; 1-32 in. zinc, 1½ cwt.

6. The construction should be able to withstand an additional weight of 30 cwt. per square for wind pressure.

7. When the carpentry forming the roof of a building is of great extent, instead of being injurious to the stability of the walls or points of support, it should be so designed that it will strengthen and keep them together.

8. Forms of roofs for various spans should couple, up to 11 ft.; couple close, to 14 ft.; collar, to 17 ft.; king post, to 30 ft.; queen post, to 46 ft.; queen and princess, to 75 ft.

9. Roof trusses should be prepared from sound, dry timber, white or red pine, free from large knots, sap, and shakes, all parts to hold sizes shown in figured dimensions, and all joints to be stub-tenoned and to fit square to shoulders. Tie-beam should be cambered ½ in. in 10 ft., and straps and bolts be of best wrought-iron. No spikes should be used in the construction except for fixing cleats.

10. Tie beams should be supported every 15 ft.

11. Struts should be taken as nearly as possible under bearing of purlin.

12. The straining beams in spans of 50 ft. and upwards require support, and a king bolt or post should be introduced.

13. To find the thickness of king post trusses,

divide the span by five and call the quotient inches. Assume 9 in. and 5 in. as the standard depth of tie beams and principal rafter respectively for 20 ft. span; add 1 in. to each for every additional 5 ft. of span. King posts and struts to be square.

14. To find the thickness of queen post trusses, divide the span by eight and call the quotient inches; if odd parts result, add 1 in. for tiles, and for slates take off the fraction. Taking the standard depth of tie beam and principal for 32 ft. span to be 11 in. and 6 in. respectively, add 1 in. to each for every 5 ft. of additional span. The struts and body of the queens to be made square.

15. Wall plates are used to distribute the weight of roof timbers, and also to act as ties to the walls. For this reason tie-beams should be cogged to the plates, the latter dove-tail-halved at the angle, and dove-tail-scarfed in longitudinal joints. Wall plates in roofs should be creosoted or otherwise protected against rot, and bedded in cement knocked up stiff.

16. Purlins should be cogged or notched on to principal rafters and not framed between them. When cogged or notched they will carry nearly twice as much as when framed.

17. The available strength of tie beams is that of the uncut fibres, and, therefore, mortises should be shallow, and all notching be avoided.

18. Scarfs in tie beams should be made between the points of support, and not directly un-

der them, as any mortises or bolt-holes at these points reduce the strength of the beam.

19. Dragon ties should be provided at the angles of hipped roofs to take the thrust of the hips and to tie in the ends of wall plates. It is best that the hip should be deep enough to birds-mouth over the angle brace.

20. Wind braces, which are diagonal ties in roofs open at the ends, as in railway stations, to withstand the overturning or racking pressure of the wind, may be of timber framed between the purlins, or iron rods running from the head of one truss to the foot of the next.

21. Hip rafters, being deeper than the common rafters, are visible inside when the roof is ceiled, and should be covered with a casing.

22. Hips should stand perfectly at an angle of 45 degrees with the plates on plan, as by this arrangement the rafters on either side are equal in length, inclination, and bevel at the ends, making the construction both symmetrical and economical.

23. When the span is of such extent that the end purlin is longer than those of the side bays, a half truss should be introduced at the center of the end, with its tie-beam trimmed into the end transverse truss.

24. All the abutment joints in a framed truss should be at right angles with the direction of thrust, and when this is parallel with the edges of

the member, the shoulders may be cut square with the back of such member.

25. To resist the racking movement in roofs, an effectual plan consists in the employment of wind ties of iron. These extend usually from the head of one principal to the foot of the next principal, but one on the same side of the roof, and again from the head of this latter principal to the foot of the first one, so that the tie rods cross one another in the form of an X. It is difficult to estimate the stress which will come upon these ties; but very small sections, say from $\frac{5}{8}$ in. to $\frac{3}{4}$ in., will generally suffice for the purpose.

26. The amount of horizontal thrust at the foot of a principal rafter depends partly upon the weight of the truss and the loads or stresses which it has to sustain, and partly upon the inclination of the rafter. The lower the pitch of the roof, the greater is the proportion of thrust to weight, so that for roofs flatter than quarter pitch stronger tie beams will be necessary.

27. In queen post trusses the position of the queen posts may vary. Generally, however, when there are no rooms in the roof, they are placed at one-third of the span from the wall.

28. When rooms are formed in queen post roofs, the distance between the queens may conveniently be half the span or more, but in such instances the depth of tie-beam should be increased.

29. The best form of roof truss to be used in

any situation may be determined by the following considerations: (1) The parts of the truss between the points of support should not be so long as to have any tendency to bend under the thrust—therefore, the lengths of the parts under compression should not exceed twenty times their smallest dimensions; (2) The distance apart of the purlins should not be so great as to necessitate the use of either purlins or rafters too large for convenience or economy; (3) The tie-beam should be supported at such small intervals that it need not be too large for economy.

30. It has been found by experience that these objects can be attained by limiting the distance between the points of support on the principal rafter to 8 ft., and upon the tie-beam to 15 ft.

31. To determine the form of roof truss for any given span, it is, therefore necessary first to decide the pitch, then roughly to draw the principal rafters in position, ascertain their length, divide them into portions 8 ft. long, and place a strut under each point of division. By this it will be seen that a king post truss is adapted for a roof, with principal rafters 16 ft. long—i. e., those having a span of 30 ft.

32. A queen post truss would be adapted to a roof with principals 24 ft. long—i. e., about 45 ft. span. For greater spans, with longer principals, compound roofs are required.

33. In the case of a roof with three spans, sub-

ject to the effects of lateral wind pressure, when supported on side walls with intermediate columns, where the situation does not permit either the addition of buttresses or of anchorage in these side walls, the horizontal reaction of the wind pressure may be taken by bracing the intermediate columns to a concrete foundation.

34. The shoulders at the foot of king and queen post trusses should be cut short when framed, to prevent the tie-beam sagging when the truss has settled, the usual allowance being $\frac{1}{2}$ in. for each 10 ft. of span.

35. Scarfing requires great accuracy in execution, because if the indents do not bear equally, the greater part of the strength will be lost; hence it is improper to use very complicated forms.

36. The simplest form of joint is, as a rule, the strongest; complicated joints are to be admired more for the ingenuity and skill of the carpenter in contriving and fitting than for their strength of construction.

37. In scarfing, when bolts are used, about four times the depth of the timber is the usual length for a scarf.

38. Scarfed tension joints should be fitted with folding wedges, so as to admit of their being tightened up. The wedges should be of oak or other suitable hard wood.

39. Galvanized iron bolts do not act upon oak,

either in sea or in fresh water, when care has been taken not to remove the zinc in driving them.

40. In calculating the weight of roof coverings, about 10 per cent should be added to weight of tiles for moisture.

41. Valley boards are used sometimes on small roofs in place of valley rafters. The main roof is continued through in the usual way, and a 1 in. by 9 in. board is nailed up the rafters on each side at the intersection of the two roofs to receive the feet of the jack rafters.

42. To carry ridge boards, the purlins, ridge, and wall-plates should oversail gable ends 12 in. or 18 in., and short purlin pieces should be cogg'd on the principals every 3 ft. for additional fixings when the barges are very wide and heavy.

43. Finals are fixed on the end of the ridge board with stub tenons, drawbore pinned, paint being applied to the tenon.

44. All openings in a roof should be trimmed; that is, cross-pieces should be framed between the two rafters bounding the opening to carry the ends of the intermediate ones cut away.

45. The trimmer, as the cross bearer is called, is fixed square with the pitch of the roof, tusk-tenoned and wedged at the ends, and the stopped rafters are stub-tenoned into it.

46. When the opening is for a chimney, provision must be made for a gutter at the top. Bearers, 3 in. by 2 in., are nailed to the sides of the

rafters, level, with their ends abutting against the chimney stack; a 1 in. gutter board is nailed on these, and a 9 in. lear board at the side on the rafters. About 3 in. up the slope a $\frac{3}{4}$ in. tilting fillet is fixed, and over this the lead is dressed, the other side being taken up the back of the chimney for 6 in., and covered with an apron flashing.

47. Other openings, such as those for skylights and trapdoors, are trimmed in the same way, and covered with wrought linings or stout frames, dove-tailed at the angles, called curbs.

48. Sizes of wall plates for 20 ft. span, $4\frac{1}{2}$ in. by 3 in.; for 30 ft., 6 in. by 4 in.; for 40 ft., $7\frac{1}{2}$ in. by 5 in.

49. Ground floor wall plates are best of oak, and a damp course should be put under them.

50. The wall plates to upper floors can be kept clear of the walls on 3 in. rough quarried stone corbbling built into the wall and projecting over $4\frac{1}{2}$ in., and supported by two courses of brick oversailing, roughly splayed off to the shape of the plaster cornice which will cover them. The floor joists are thus kept clear of the wall and can be strengthened by solid strutting between the ends.

51. All wall-plates should be bolted down to the wall, and the bolts should be built into the wall as shown in Fig. 306, and should be fitted with nut on top to bind down the plate.

52. Beams or roof trusses should not rest over

openings. They should be placed with their ends in pockets in the wall, and resting on stone templates.

53. They should frame into girders with stub tusk tenons and oak pins, or, better, should hang in iron stirrups.

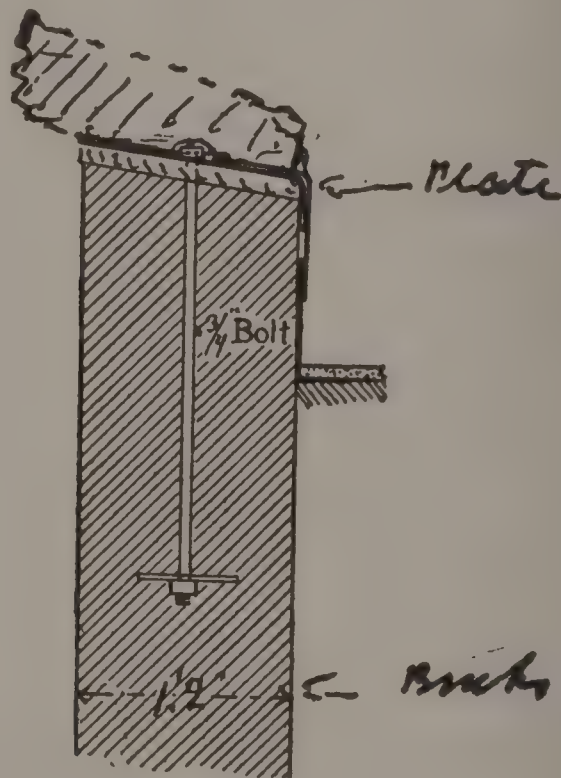


Fig. 306.

54. Binders should not be more than 6 ft., nor girders more than 10 ft. apart.

These general rules should be followed as closely as possible in the making of heavy timber roofs, but of course, must be changed or adapted to suit the many various conditions that are sure to arise.

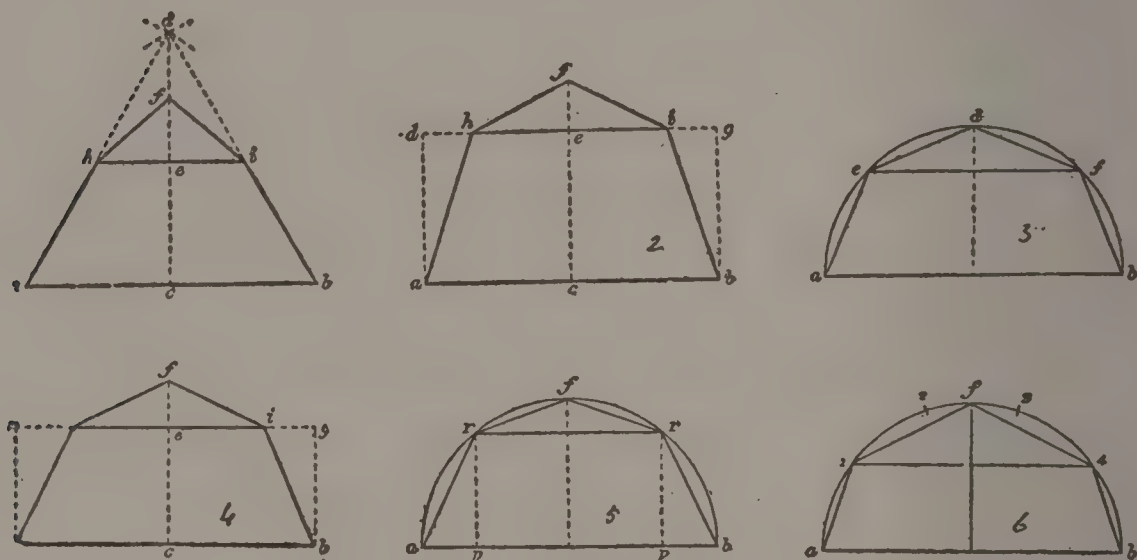
There are many kinds or forms of roofs, a few of which I show in the sketches submitted which are original types. When these are crossed, mixed, modified or combined in one building or group of buildings, the results are not only beyond all computation, but are not unfrequently fearful and wonderful to behold.

To diminish the excessive height of roofs, their sharp summit is sometimes suppressed and replaced by a roof of a lower slope. These roofs have the advantage of giving ample attic space with a smaller height than would be required by a V-roof. They are variously known as "curb" or "gambrel" roofs, and "Mansard" roofs, the latter name being usually confined to those roofs in which the lower slopes form angles of not less than 60 degrees with the horizontal plane, while roofs of smaller pitch are known as "curb" or "gambrel" roofs.

The Mansard roof may be described in several ways: (See Fig. 307.)

The triangle $a d b$, represents the profile of a high-pitched roof, the height being equal to the base, and the basal angles being therefore 60 degrees each. At the point e , in the middle of the height $c d$, draw a line horizontally $h e i$, parallel to the base $a b$, to represent the upper side of the tie-beam, and make $e f$ equal to the half of $e d$; then $a h f i b$ will be the profile of the Mansard roof.

Make $c e$, the height of the lower roof, equal to half the width $a b$, and construct the two squares $a d e c$, $c e g b$; also make $d h$, $e f$, and $g i$ each equal to one-third of the side of either square; then will $a h f i b$, be the profile required.



Methods of describing Mansard Roofs

Fig. 307.

On the base $a b$ draw the semicircle $a d b$, and divide it into four equal parts, $a e$, $e d$, $d f$, $f b$; join the points of division, and the resulting semi-octagon is the profile required. The slopes of the upper roof form angles of only $22\frac{1}{2}$ degrees, and this roof is therefore considerably less than "quarter-pitch," and would be unsuitable for covering with slates, tiles, shingles, etc.

Whatever be the height of the Mansard $c e$, or $b g$, or $g i$, equal to the half of that height, and the height $e f$ of the false roof equal to the half of $e i$.

The upper roof, therefore, is exactly "quarter-pitch."

The form of the Mansard roof, it will be seen, may be infinitely varied, according to the fancy of the designer, the purposes for which the roof-space is required, and the nature of the roof-covering. In many cases the lower slopes are made of curved outline, as may be seen later on, or as shown in No. 6, in the sketches.

It is now in order to give a few examples of a practical nature, and I will endeavor to do this without confusing the workman with a network of figures or mathematical formula: Like floors, roofs may be divided into three kinds, according to the arrangement of their timbering, as follows:

1. Single-Rafter Roofs.
2. Double-Rafter Roofs.
3. Triple-Rafter Roofs.

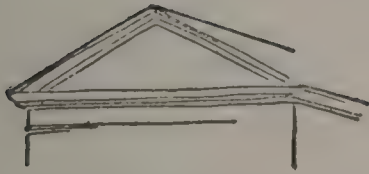
1. Single-Rafter Roofs are such that one roof covering is supported upon a single system of rafters not greater than two feet from center to center apart. It should be used only when the span is not greater than 26 feet. A number of examples of this kind of a roof are shown in Fig. 308. Other similar examples will be shown later on.

Lean-to roofs are found in a single slope, as shown at A, the upper end of the rafters being spiked to a wall-plate or bond timber supported

on a corbel, and the lower end bird's-mouthed to a wall-plate on the lower wall. This roof should not be used for a span greater than 14 feet, unless the rafters are braced or otherwise supported near their centers. When a wall occurs conveniently near the center of the building, the roof may slope down towards the center, where a gutter or trough may be placed to carry off the rain or snow water. A double lean-to roof of this kind is sometimes called a V-roof, on account of the shape of its section.

Couple or span roofs are formed as shown at B, the upper ends of the rafters being abutted against and spiked to a ridge board, while the lower ends are either bird's-mouthed over and spiked to a wall-plate, or crow-footed over the outside of the plate and left projecting beyond the wall to form an eave for cornice. This form of roof should only be used on short spans unless the walls are thick and firm, or the rafters are tied at the bottom to keep from spreading, as an outward thrust is exerted by the feet of the rafters.

Couple close roofs are similar to the previous one, but have the feet of the rafters tied together by means of tie-beams fastened to the rafters, as shown at C Fig. 308. The soundest roof is procured by tying the feet of every pair of rafters, and indeed, this is necessary when a ceiling is to be attached to the ties; but when a roof is open a tie is rarely used more frequently than one for



Gable Roof with Pediment.



Semicircular Arch Roof.



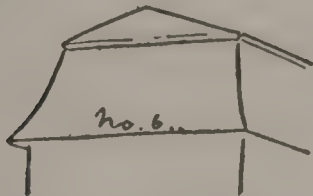
*Suggestions of Dormer Windows
in Roofs.*



The Pent or Shed Roof.



Double Pitch or Gable Roof.



French or Mansard Roof.



Pyramidal Turret.



*Hip Roof with Broken
Rafters.*



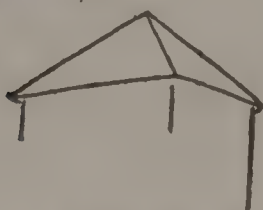
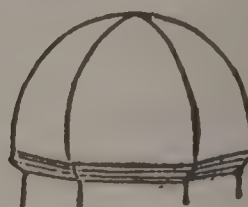
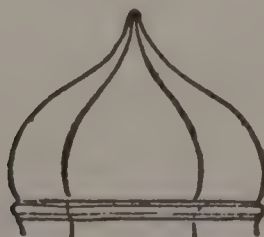
*Ornamented Gable in the
English Style.*



Gable with Ornamented Verge-Boards.



Queen Anne (or Mongrel?)

*Typical Swiss Roof.**Curb or Gambrel Roof.**Gable Roof with Horizontal
Cornice Returns.**Fragment from an Ancient
Castle.**Hip or Pyramidal Roof.**Arched Turret.**Combined Hip and Gable Roof.**Gable and Shed Roof
Combined.**A Bell Shaped
Turret.**Moresque Turret.*

every third or fourth pair of rafters. This roof may be employed for spans up to 30 ft. At C, a roof is shown over a span of 26 feet, but if larger

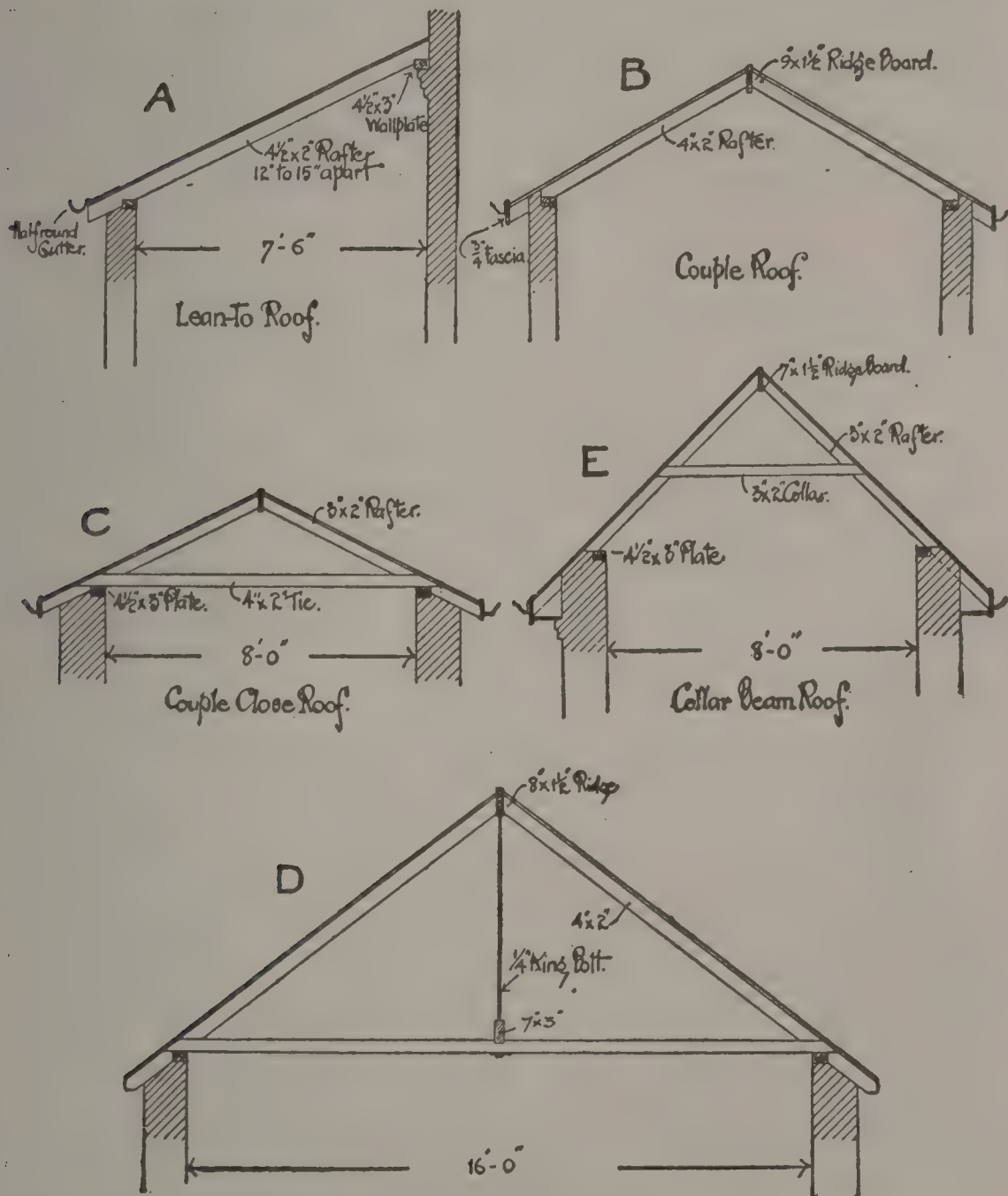


Fig. 308.

roofs are to be constructed in this form the ridge-board should be one inch deeper for every foot additional to the span. See Plates 1 and 2, "Types of Roofs."

When the span is unusually great, it is more economical to suspend the ties to rafters every six or eight feet. The ties between the bolts are housed into and spiked to a horizontal timber which is suspended by the bolts, as shown at D. When suspension bolts are used the depth of the ties may be half of that given in the foregoing rule.

Collar-beam roofs are formed like couple roofs with a beam or joist spiked or bolted to the rafters as shown at E. This type of roof is employed when a greater amount of head room is required than can be obtained in a couple-close roof, but it is not a sound roof, as it always exerts a thrust upon the walls. The collars being used to prevent the rafters from sagging, are in a state of compression, and do not tie the rafters together as they are generally supposed to do.

Double or Purlin roofs are composed of two series of timbers, as shown in Fig. 309, in which it will be seen that the roofs are composed of common rafters supported by means of purlins, for which reason this kind of roof is often called a purlin roof.

This sort of roof may be used for any span whatever when the gable walls are not too far apart, or when the rafters can be supported by studding from floor or central wall.

The outline of this roof, Fig. 309, shows it up as a "Mansard roof," the upper portion being

practically a "couple-close" roof, the rafters resting upon purlins which are tied together by the ceiling joists, by bolts or heavy spikes. The lower rafters are practically independent of the upper portion of the roof, being merely bearers for the roof covering, and are secured by spiking them to the upper end of the purlin, and at the lower end to the wall-plate. The feet of these lower rafters do not need tying, as their inclination to the vertical is so small.

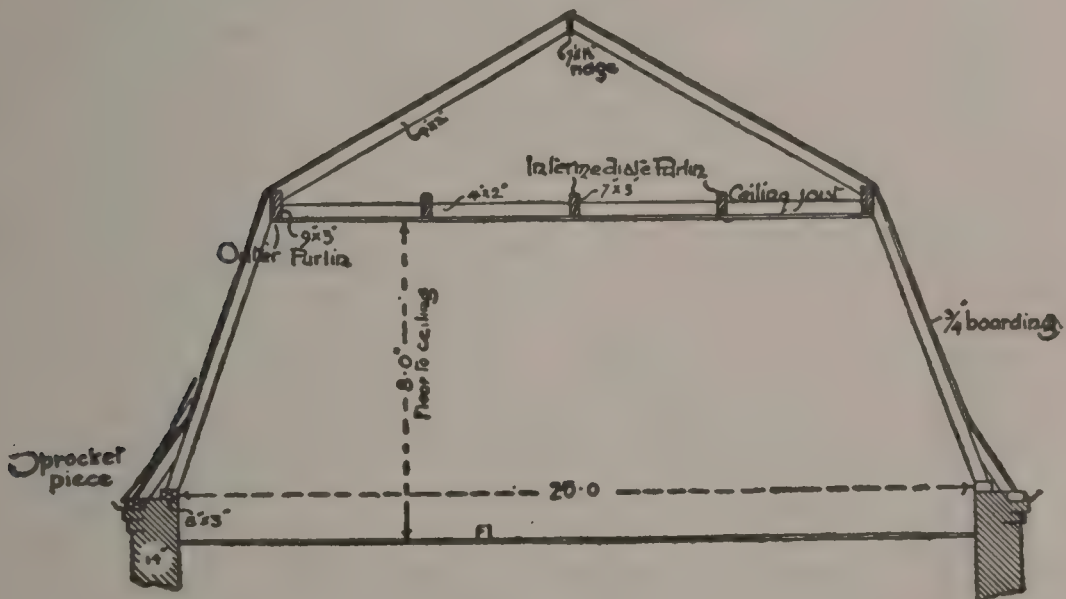


Fig. 309.

A couple of good purlin roofs suitable for many places, are shown in Figs. 310 and 311.

The one shown at Fig. 310 is known as a queen post truss, but having queen rods instead of posts. Two additional braces and one rod have been added to the members of the truss so as to take up the half load between the points F and H. According to the conditions of loading it has been

about 7280 pounds will be concentrated at or near the points E and C. This load will cause a stress of about 13,500 pounds compression in each of the rafters A E and C B; also a compression strain of 11,300 pounds in the straining beam E C, as well as a tensile strain of about 11,300 pounds in the tie beam A B. In computing the strains due to the floor load, 200 pounds per square foot of floor area have been taken, including the weight of the flooring and the weight of the truss itself. The following table gives the strain on all the members of the truss due to both loads:

	Pounds.
Main rafters A E and C B.....	65,450
Straining beam E C.....	41,800
Tie beam A B.....	55,050
Suspension rod D G.....	16,800
Braces D F or D H.....	15,700
Rods E F or C H.....	28,000

These figures are, of course, only approximate, owing to the assumptions which have been made and the smallness of the diagram submitted, but they are of sufficient accuracy to draw the following conclusions: First, that the truss as shown in Fig. 310, is sufficiently strong to carry with entire safety the assumed loads here quoted, provided, however, the points of supports at A and B are sufficiently strong. From the diagram it appears as if the tie beam was tenoned into an upright post at each end and the parts pinned together. Con-

sidering the heavy load liable to be placed on a truss of this kind, it would seem doubtful whether this point is strong enough. In Fig. 311 I present a view of a truss in which an attempt has been made to improve on Fig. 310, using the same amount of material. It will be seen that the depth has been increased somewhat, which insures greater rigidity, and also gives the rafters less in-

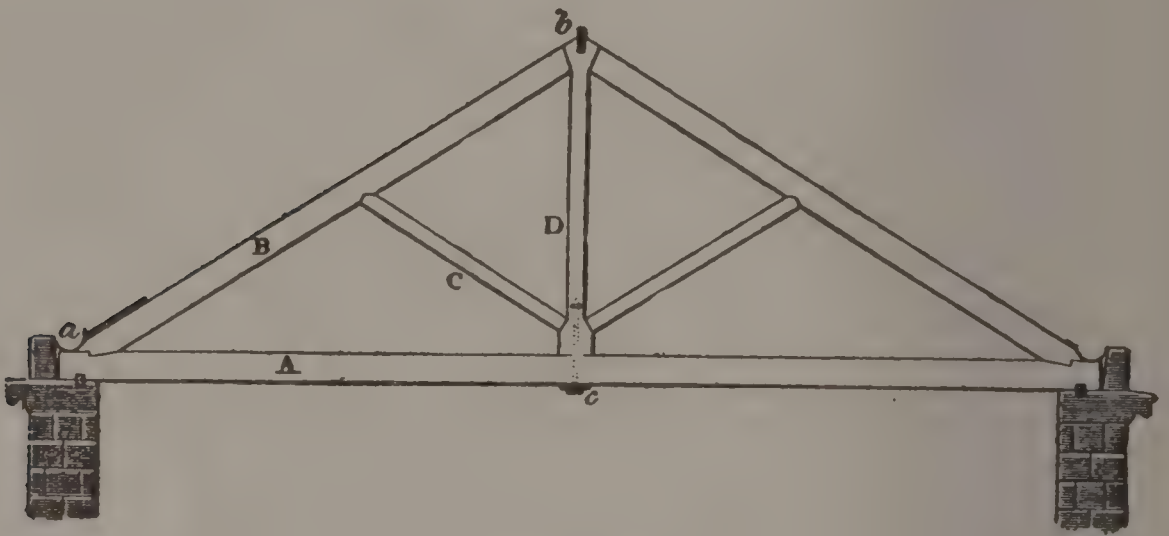


Fig. 312.

clination to the horizontal, thus causing the strain to become less under the same load. It also affords better facilities for passing through the space between the members from one portion of the floor to the other. Again, the purlins rest directly on the trusses, thus doing away with the long 4x5 inch braces and also the short 7x7 inch posts. The small 4x4 inch braces shown in Fig. 310, can be dispensed with, as they receive no strains whatever.

The following diagram, Fig. 312, shows the elevation of a king-post roof suitable for a span of 35 or 40 feet.

By the rules for calculating the sizes of timbers the dimensions will be found to be as follows:

A, Tie-beam	13x5 inches.
B, Principal rafters	8½x5 inches.
C, Struts	4x2½ inches.
D, King-post	7½x5 inches.

Fig. 313 is the design for a king-post roof, for a span of from 40 to 45 feet.

The purlins here are shown framed into the principals, a mode of construction to be avoided, unless rendered absolutely necessary by particular circumstances.

The scantling, as determined by the rules, is as follows:

Principal rafters	10x5 inches.
Tie-beam	11½x6 inches.
King-post	7¾x6 inches.
Struts	4x2½ inches.
Purlins	10x6 inches.

The principals being 10 feet apart.

Fig. 314 shows a compound roof for a span of 40 feet. It is composed of a curved rib c c, formed of two thicknesses of 2-inch plank bolted together. Its ends are let into the tie-beam; and it is also firmly braced to the tie-beam by the king-post and

suspending pieces B B, which are each in two thicknesses, one on each side of the rib and tie-beam, and by the straps a a. A is the rafter; d,

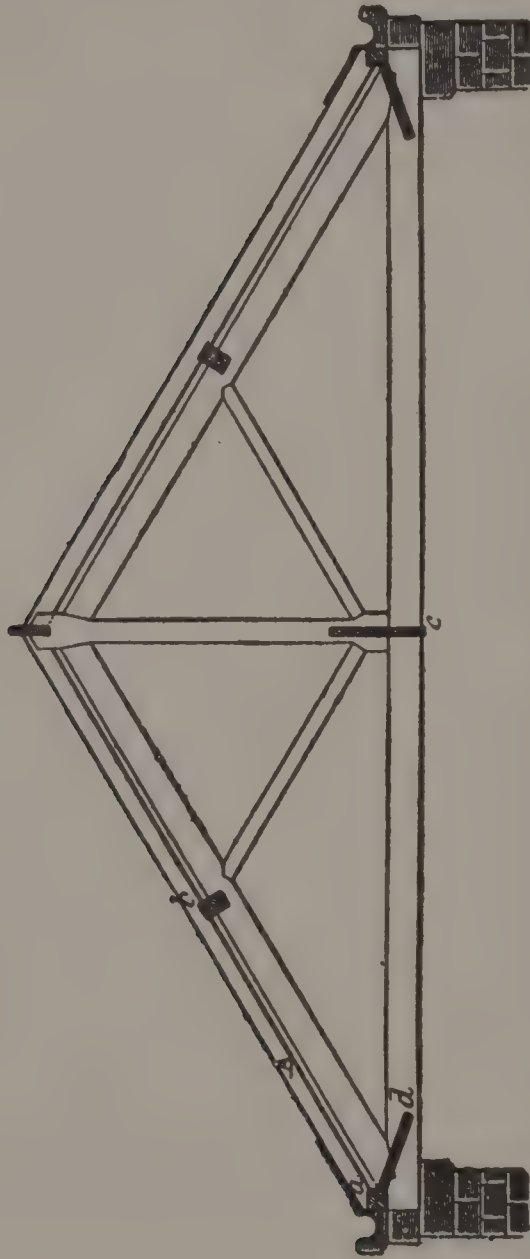


Fig. 313.

the gutter-bearer; c and b, the straps of the king-post. The second purlins, it will be observed, are carried by the upper end of the suspending pieces B B.

Fig. 315 shows a queen-post roof for a span of 60 feet. This truss is designed on the same principle as Fig. 311, that is, with queen-posts B, and additionally strengthened by suspension post A. These are strapped up to the tie-beam by wrought-iron straps, made of $\frac{3}{8}$ by 3-inch iron, bolted to the posts. The pitch of the principal rafter is less somewhat than over Fig. 311.

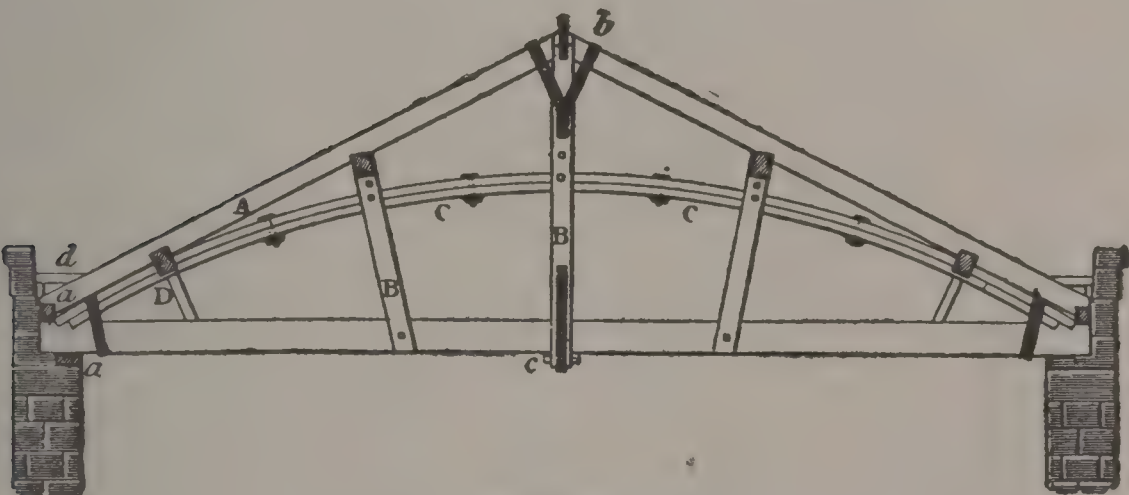


Fig. 314.

The scantlings are as follows:

Principal rafters	11	x 6	inches
Tie-beam	12½	x 6	inches
Queen-post B	8	x 6	inches
Suspending-post A	3½	x 3½	inches
Struts (large)	4½	x 3½	inches
Struts (small)	3½	x 2½	inches

Figs. 316 and 317 show the use and application of wrought iron in those portions acting as ties. These trusses are suitable for railroad sheds, or

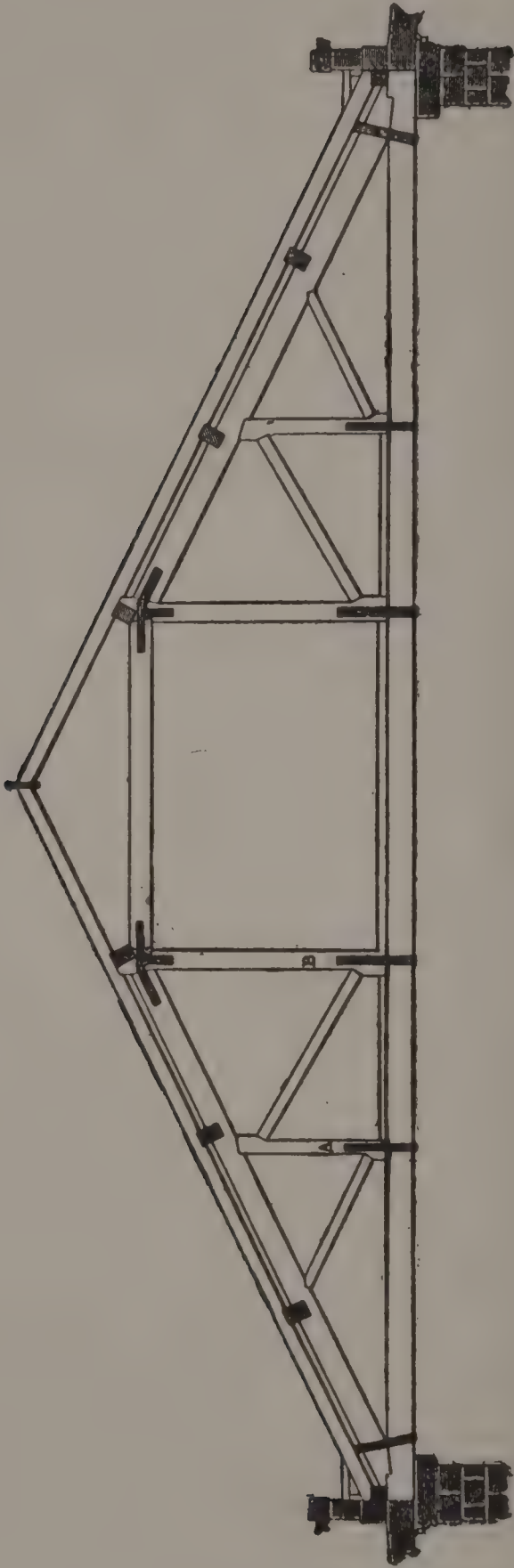


Fig. 315.

where it is desirable to have the tie-rods raised from a level line so as to give greater height in the center. The sizes of timber for design 316 are as follows:

Principal rafters	12	x 8	inches
Struts	8	x 8	inches
Purlins	10	x 4	inches
Common rafters	4½	x 2	inches
Tie-rod and suspending rod...	1½	in.	diameter.

The timbers for design 317 are as follows:

Principals	14	x 8	inches
Collar-pieces	11	x 3	inches

(One on each side of rafter.)

Purlins	16	x 4	inches
Tie-rods and suspending-rod..	1¾	in.	diameter.

The span of truss, Fig. 316, is 36, and that of Fig. 317, 45 feet.

Fig. 318 shows a platform roof of 35 feet span. The tie-beam in this example is scarfed at a and b, and the center portion of the truss has counter-braces, c c. The longitudinal pieces, e e, are secured to the heads of the queen-posts, and the pieces d carry the platform rafters A. In this connection it may be of importance to the better understanding of the principles of strength entering into combination roof trusses to give Tredgold's rules for finding the proper dimensions of the timbers forming king and queen-post trusses, which are quite simple.

Rule.—Multiply the square of the length in feet by the span in feet, and divide the product by the cube of the thickness in inches; then multiply the quotient by 0.96 to obtain the depth in inches.

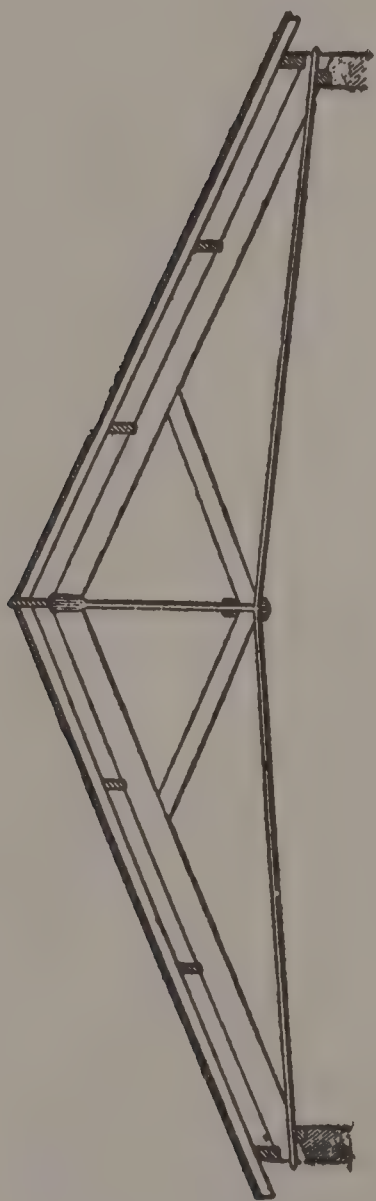


Fig. 316.

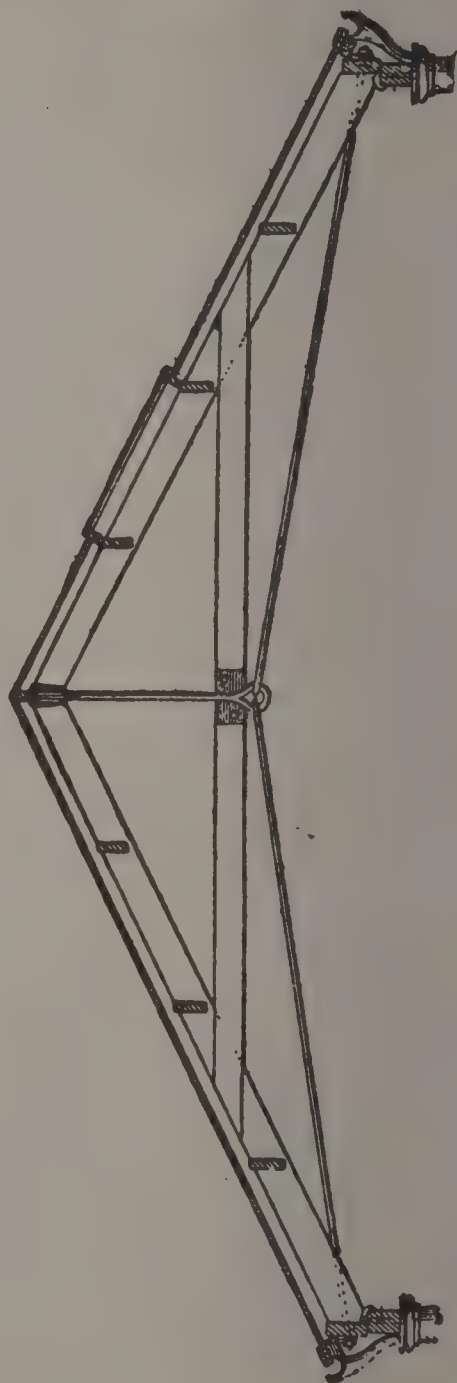


Fig. 317.

Mr. Tredgold gives also the following rule for the rafters, as more general and reliable:

Multiply the square of the span in feet by the distance between the principals in feet, and divide the product by 60 times the rise in feet; the quotient will be the area of the section of the rafter in inches.

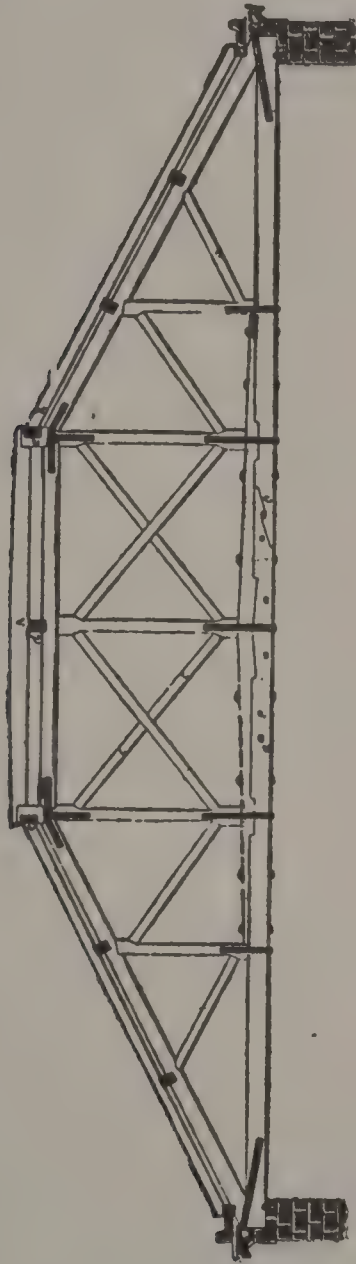


Fig. 318.

If the rise is one-fourth of the span, multiply the span by the distance between the principals, and divide by 15 for the area of section.

When the distance between the principals is 10 feet, the area of section is two-thirds of the span.

To find the dimensions of the tie-beam, when it has to support a ceiling only:

Rule.—Divide the length of the longest unsupported part by the cube root of the breadth, and the quotient multiplied by 1.47 will give depth in inches.

To find the dimensions of the king-post:

Rule.—Multiply the length of the post in feet by the span in feet; multiply the product by 0.12, which will give the area of the section of the post in inches. Divide this by the breadth for the thickness, or by the thickness for the breadth.

To find the dimensions of struts:

Rule.—Multiply the square root of the length supported in feet by the length of the strut in feet, and the square root of the product multiplied by 0.8 will give the depth, which, multiplied by 0.6, will give the thickness.

In a queen-post roof. To find the dimensions of the principal rafters:

Rule.—Multiply the square of the length in feet by the span in feet, and divide the product by the cube of the thickness in inches; the quotient multiplied by 0.155 will give the depth.

To find the dimensions of the tie-beam:

Rule.—Divide the length of the longest unsupported part by the cube root of the breadth, and the quotient multiplied by 1.47 will give the depth.

To find the dimensions of the queen-posts:

Rule.—Multiply the length in feet of that part of the tie-beam it supports; the product, multiplied by 0.27, will give the area of the post in inches; and the breadth and thickness can be found as in the king-post.

The dimensions of the struts are found as before.

To find the dimensions of a straining-beam:

Rule.—Multiply the square root of the span in feet by the length of the straining-beam in feet, and extract the square root of the product; multiply the result by 0.9, which will give the depth in inches. The beam, to have the greatest strength, should have its depth to its breadth in the ratio of 10 to 7; therefore, to find the breadth, multiply the depth by 0.7.

To find the dimensions of purlins:

Rule.—Multiply the cube of the length of the purlin in feet by the distance the purlins are apart in feet, and the fourth root of the product will give the depth in inches, and the depth multiplied by 0.6 will give the thickness.

To find the dimensions of common rafters, when they are placed 12 inches apart:

Rule.—Divide the length of bearing in feet by the cube root of the breadth in inches, and the quotient multiplied by 0.72 will give the depth in inches.

It may be well to note some practical memor-

anda of construction which cannot be too closely kept in mind in designing roofs.

Beams acting as struts should not be cut into or mortised on one side, so as to cause lateral yielding.

Purlins should never be framed into the principal rafters, but should be notched. When notched they will carry nearly twice as much as when framed.

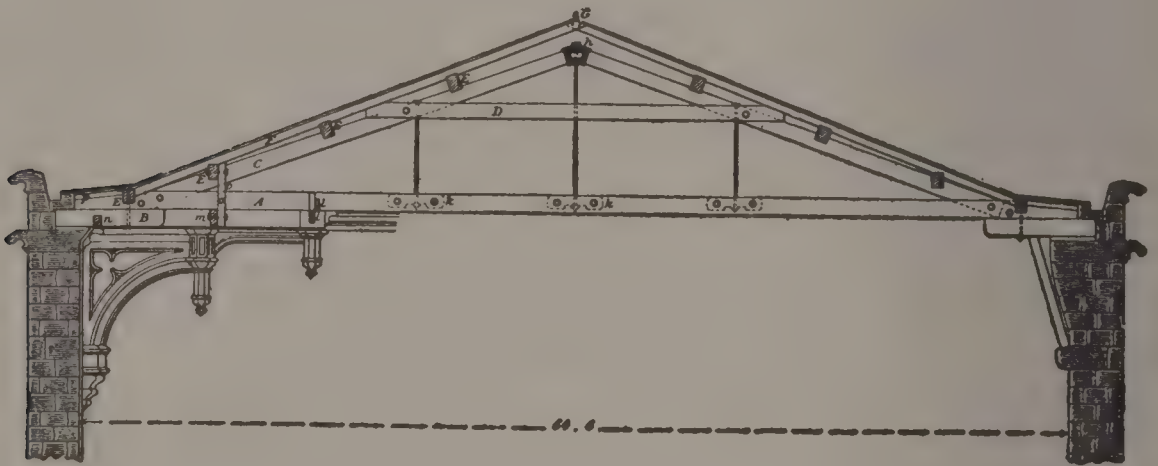


Fig. 319.

Purlins should be in as long pieces as possible.

Horizontal rafters are good in construction, and cost less than purlins and common rafters.

At Fig. 319 I show one of the principals of the roof of a church. The following are the dimensions of the timbers:

There are five principal trusses, placed 14 feet apart.

A, tie-beam, in two thicknesses, 14 x 10 inches.

Principal rafters, 13 inches deep at bottom, 11½

inches at top and $10\frac{1}{2}$ inches thick. The rafters bear on oak abutment pieces $11 \times 7\frac{1}{2}$ inches, bolted between the ties and to each other.

D, collar-beam, in two thicknesses, one on each side of the rafter, and notched and bolted, $12 \times 5\frac{1}{2}$ inches each.

E, purlins. The two lower, $13 \times 6\frac{1}{2}$ inches; the upper, $11\frac{1}{2} \times 8\frac{1}{2}$ inches; notched on the rafters and bolted.

F, common rafters, $5\frac{1}{2} \times 2\frac{1}{2}$ inches, and 13 inches apart.

The discharging posts between the bracket pieces and the stone corbel are of oak, 6 inches square.

The dimensions of the ironwork are as follows: King-rod, $1\frac{3}{4}$ in. square, with a cast-iron key piece at top.

Queen-rods, $1\frac{1}{2}$ in. square, having solid heads at rafters and secured at foot by being passed through solid oak pieces k, placed between flitches of the tie-beam and securely bolted, and there fastened with cast-iron washers and nuts.

Four bolts at abutment end of ties.... $7\frac{1}{2}$ in. sq.

Two bolts at each oak piece, for sus-

pending rods $\frac{7}{8}$ in. sq.

Two bolts at each end of collar-beam.. $\frac{7}{8}$ in. sq.

Purlin bolts $\frac{3}{4}$ in. sq.

The following example, Fig. 320, is taken from Bell's Carpentry, and shows a strong roof, one

that will suit admirably for a factory or machine-shop where there is likely to be jars or shakes caused by the machines in motion, or the rolling in of heavy freight. This roof may have a span of fifty feet, or even more if necessary. The principal rafter is set back a foot from the end of the tie-beam to give room for the wall-plate; the rise of the roof is 5 inches to the foot. In framing roofs of this kind the supporting rods should be furnished before commencing the frame; for then

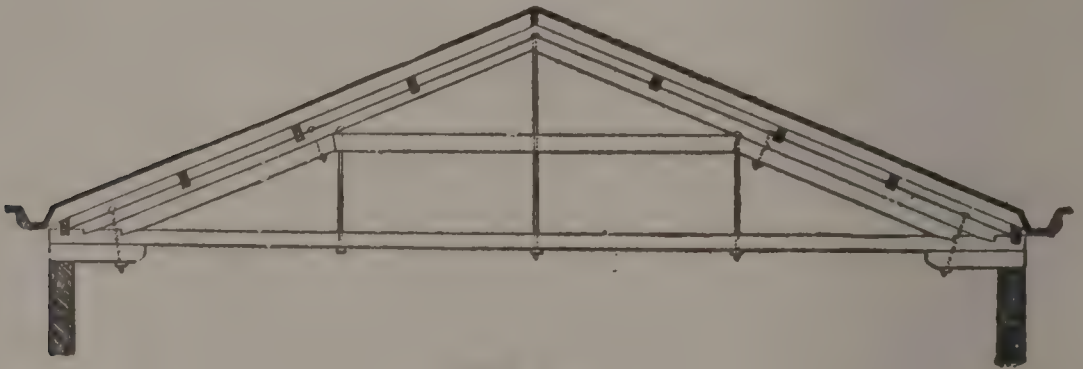


Fig. 320.

the length of the short principal rafters and that of the straining beam can be regulated or proportioned according to the length of the rods. It is best, however, for the middle rod to be twice the length of the short ones, reckoning from the upper surface of the beam to the upper surface of the principal rafters, and allowing one foot more to each rod for the thickness of the beam, and the nut and washer. For example, the middle rod is 11 feet long and the short ones 6 feet each; which, after allowing 1 foot, as above mentioned, makes

the length of the long one, above the work side of the beam, twice that of the short ones.

The length of the rod above the beam is the rise of the rafter, and the distance from the center of the rod to the foot of the rafter is the run of the rafter; the length of the rafter can, therefore, be found by the usual way.

To find the length of the straining beam, add the run of the short principal rafter to the lower end bevel of the long one; subtract this run from the run of the long principal, and the difference will be half the length of the straining beam.

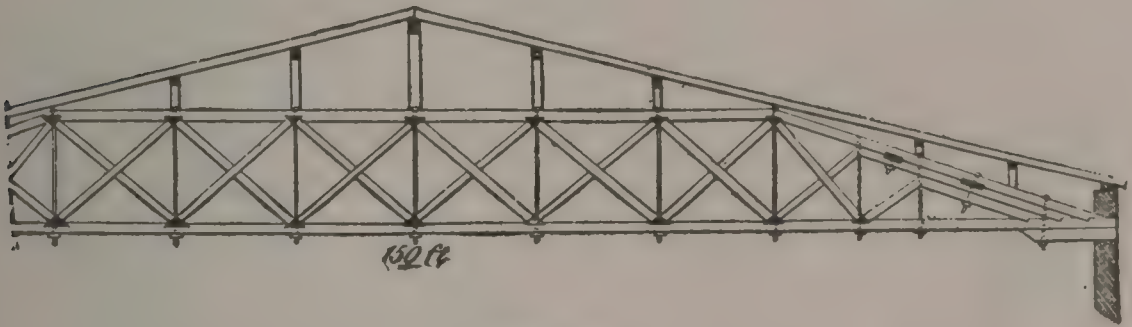


Fig. 321.

The bolsters under the ends of the tie-beams are of the same thickness as that, and about 5 feet long.

Figs. 321 and 322 exhibit designs of roofs in an improved style, particularly adapted to those of a great span, as they may be safely extended to a very considerable width, with less increase of weight, and less proportionate expense, than any of the older styles. The principle on which they

are constructed is essentially the same as that of the Howe Bridge. The braces are square at the ends, the hardwood blocks between them being beveled and placed as shown in the diagrams. Each truss of this frame supports a purlin post and plate, as represented.

These roofs are easily made nearly flat, and thereby adapted to metallic covering, by carrying the walls above the tie beams to any desired height, without altering the pitch of the principal rafters,

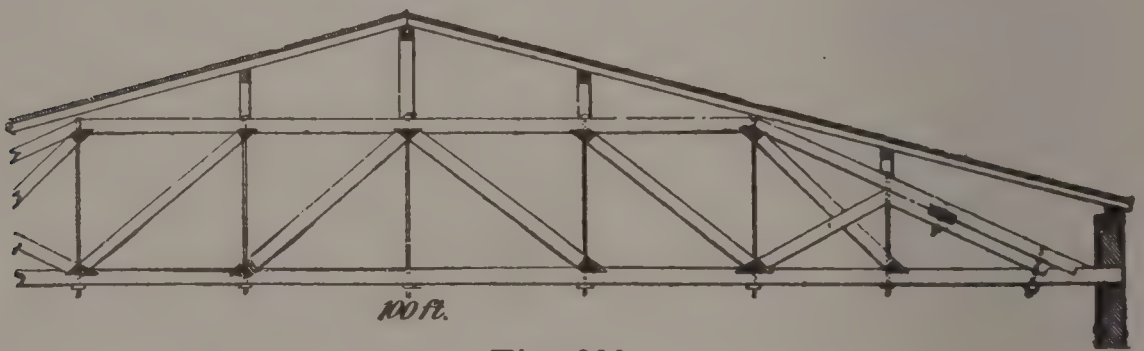


Fig. 322.

which ought to have a rise of at least 4 inches to the foot, to give sufficient brace to the upper chord or straining beam.

Fig. 321 is represented with counter-braces; and Fig. 322 without them. The counter-braces do not add anything to the mere support of the roof, and are entirely unnecessary in frames of churches, or other public buildings, where there is no jar; but they may very properly be used in mill frames, or other buildings designed for heavy machinery.

The illustrations do not show the whole length of the roof, but enough of the construction is shown to enable the workman to design the whole truss.

Figs. 323, 324 and 325 exhibit three steep or gothic roofs suitable for small churches, chapels or similar buildings having from 40 to 45 feet

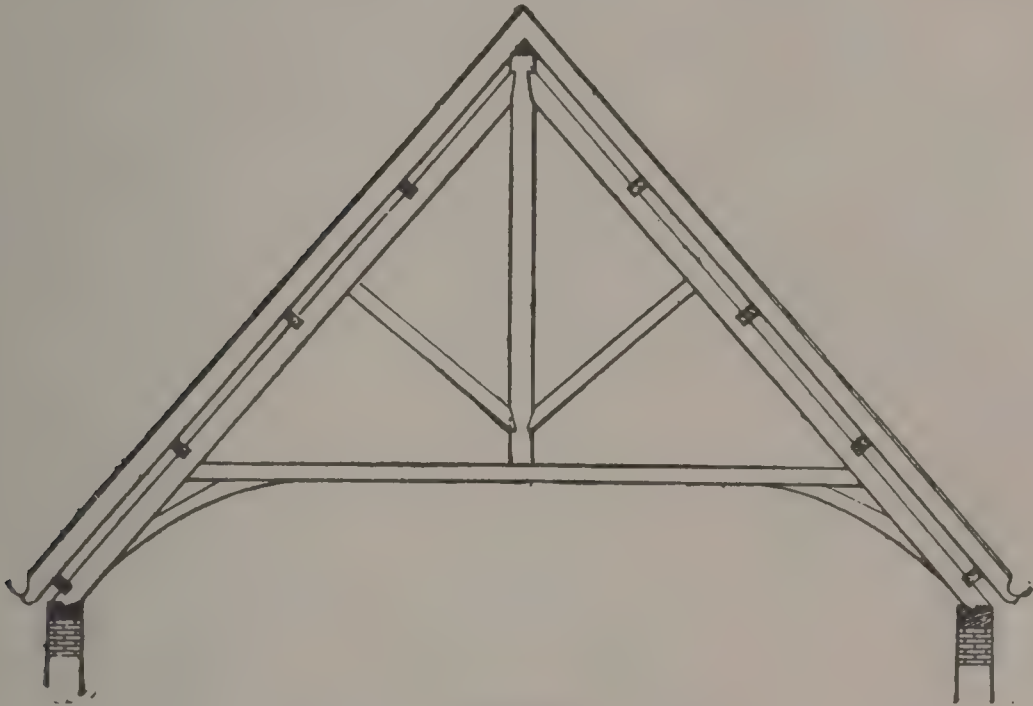


Fig. 323.

span. Fig. 323 is built entirely of wood, and Fig. 324 is of wood strengthened with iron straps and bolts. Fig. 325 contains less wood than either of the two preceding examples, but is supported by iron rods and is decidedly the stronger roof of the three. Fig. 323 makes a neat, cheap and very simple plan, and is sufficiently strong enough for efficient service on any ordinary building having a span of not more than 35 or 45 feet.

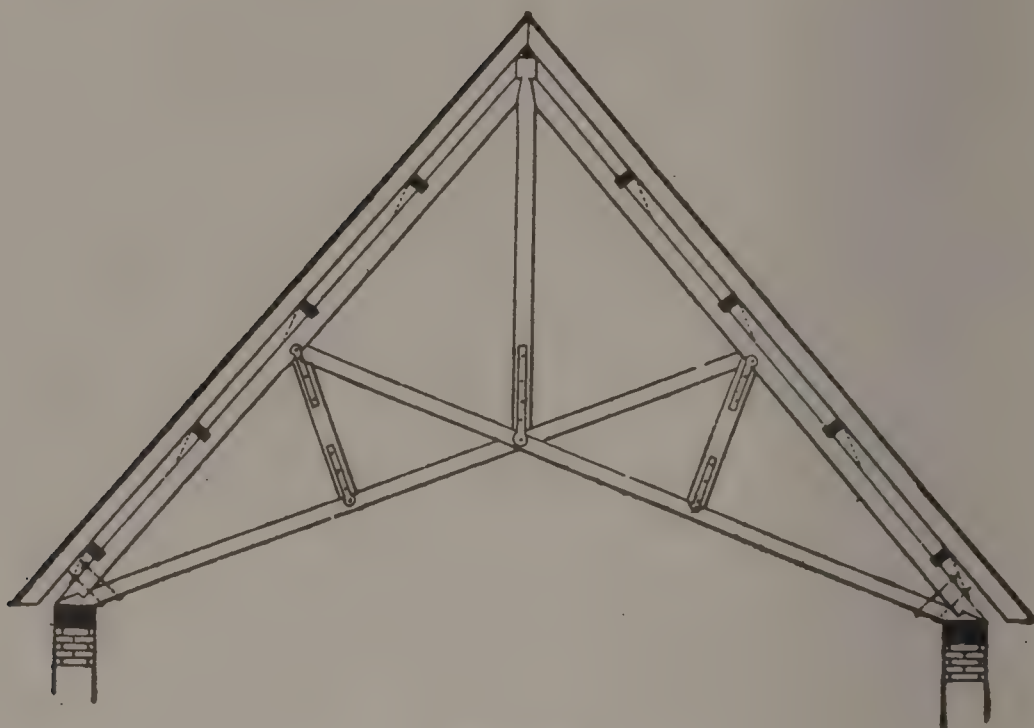


Fig. 324.

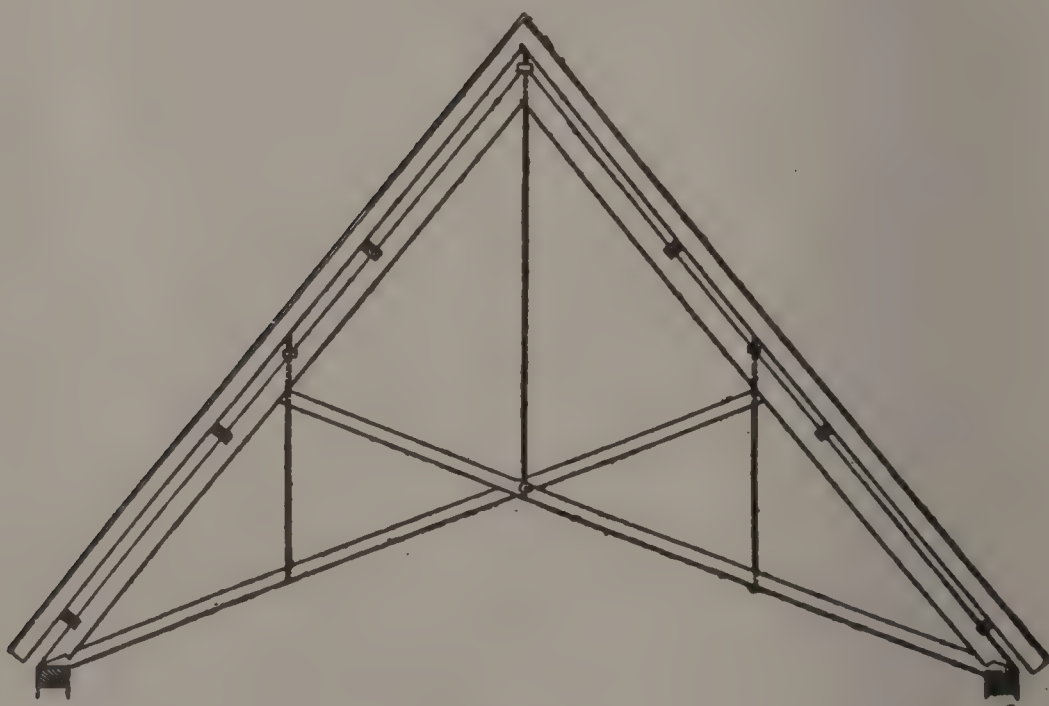


Fig. 325.

Fig. 326, which shows an arched ceiling, may be formed of 2-inch planks from 6 to 10 inches wide, which should be planed to a regular thickness and then wrought to the proper curve on the edges as shown. The forms thus made are laid one over the other, breaking all joints, and may be in two or more thicknesses, and then spiked or bolted together as may be desired. Intermediate forms

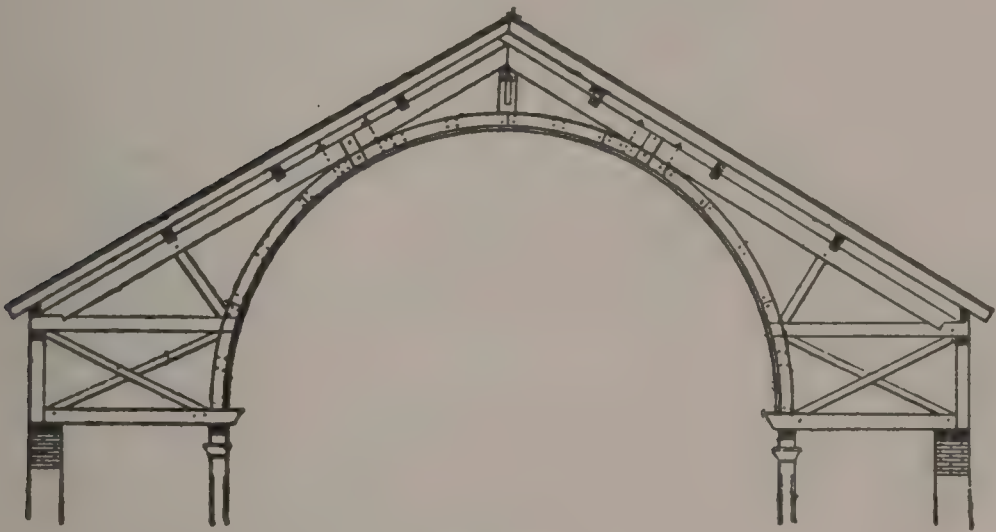


Fig. 326.

of lighter and rougher material must be made to be placed between the finished arches to carry lath and plaster, and should be spaced so that their centers would be 16 inches apart. In Fig. 327 the arch should be formed from planks 3 inches thick and 12 inches wide and in three courses; have all joints broken or spliced and then well spiked or bolted together and may be fastened to the roof braces as shown. Inter-

mediate arches or ribs will be required to carry lath and plaster, same as in Fig. 326. Either of these roofs will answer quite well for a span from 65 to 70 feet between the supporting column.

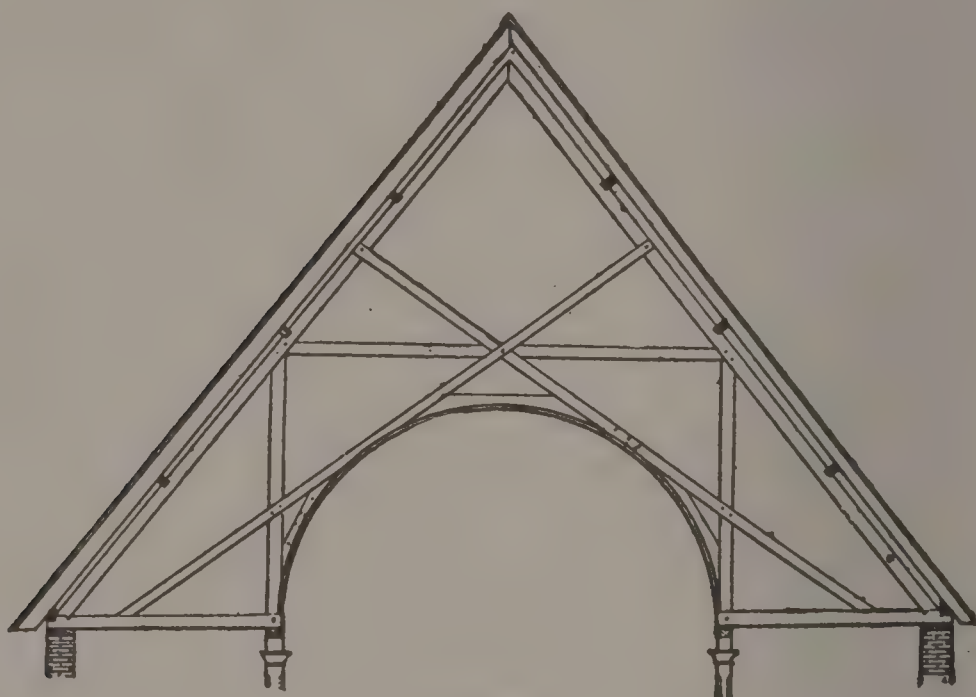


Fig. 327.

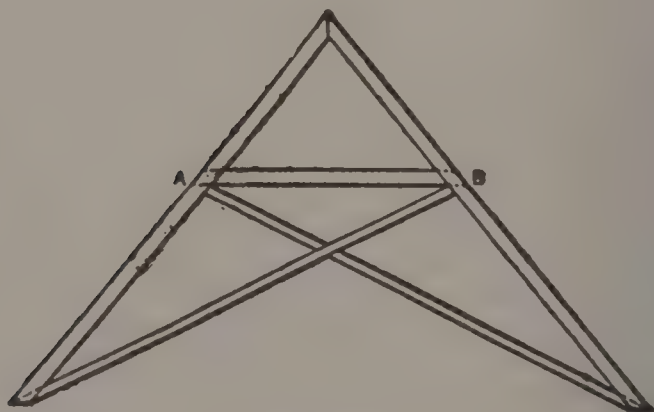


Fig. 328.

Fig. 328 shows a cheaply made roof, and one that is suitable for small spans. This is sometimes called a scissor roof, because of the two main

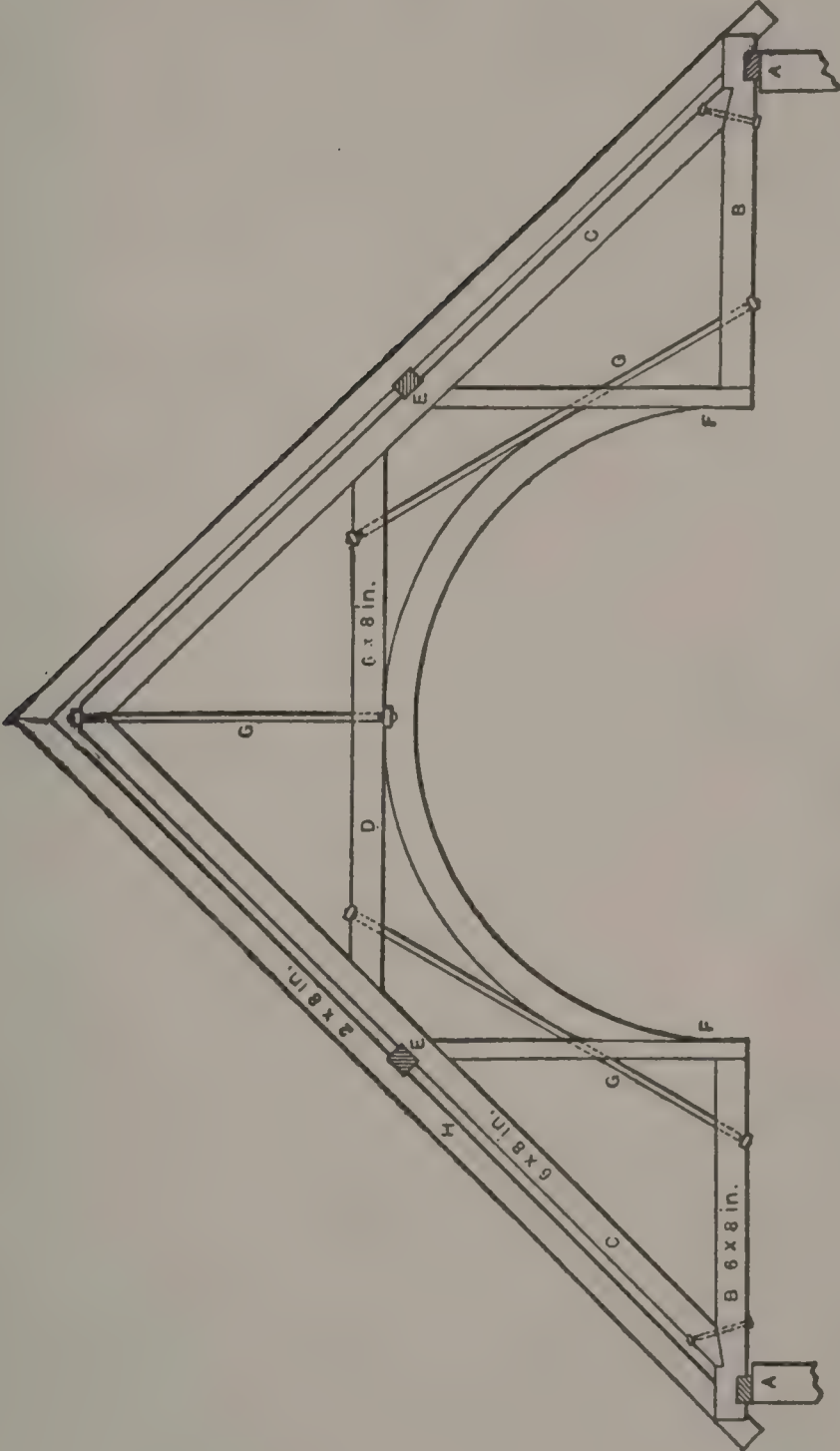


Fig. 329.

braces which tie the feet, collar beam and rafters together, cross in the center.

A different roof, and a very strong one, if the workmanship is good, is shown at Fig. 329. In this A A represents the wall plates, which are 4 by 8 inches. B B is the bottom cord of truss, 6 by 8 inches. C C are truss rafters, also 6 by 8 inches in section. D is the top cord of truss of the same dimensions. E E shows the position of the second plates, which are 6 by 6 in. in size and are notched on to the truss rafters. F F are

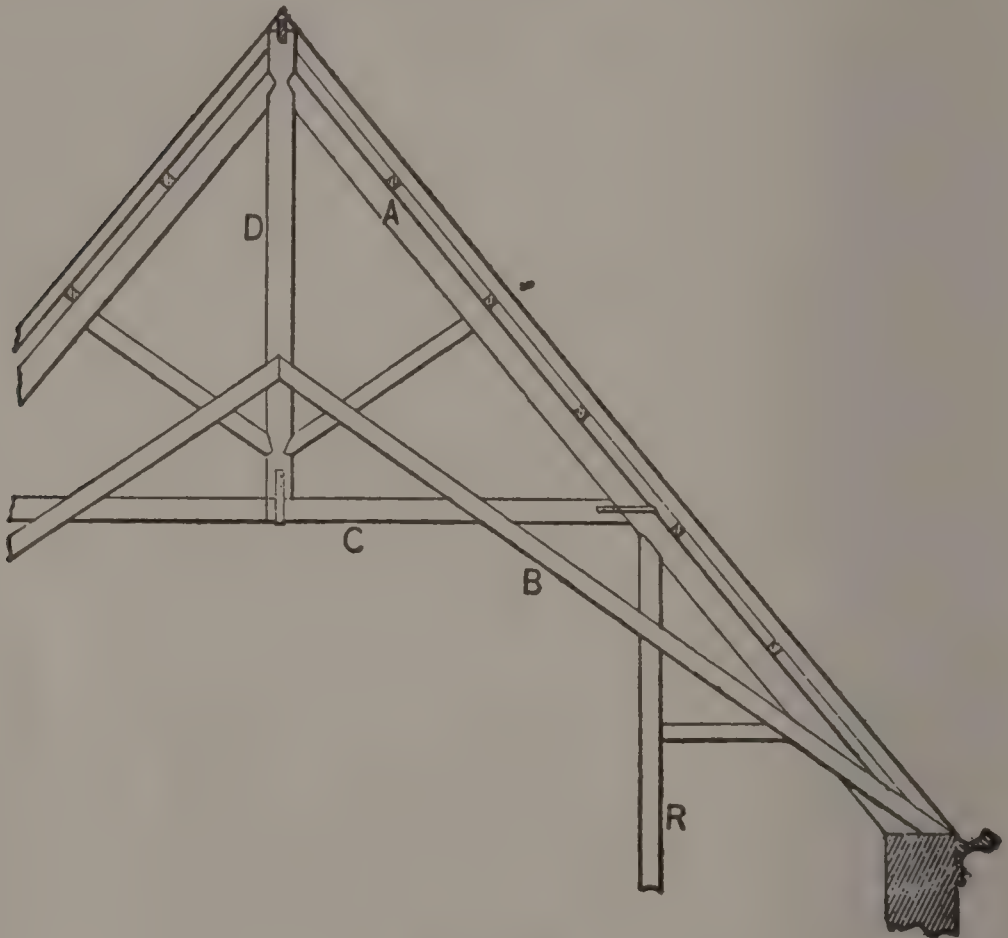


Fig. 330.

8 inches in section. C C are truss rafters, also 6 by 8 inches in section. D is the top cord of truss of the same dimensions. E E shows the position of the second plates, which are 6 by 6 in. in size and are notched on to the truss rafters. F F are

braces framed at the top into C C. G G G are iron rods used in strengthening the truss. Each truss rafter is bolted at the foot to the cord. The trusses should be placed about 10 feet apart. The roof rafters should be about 22 inches between centers.

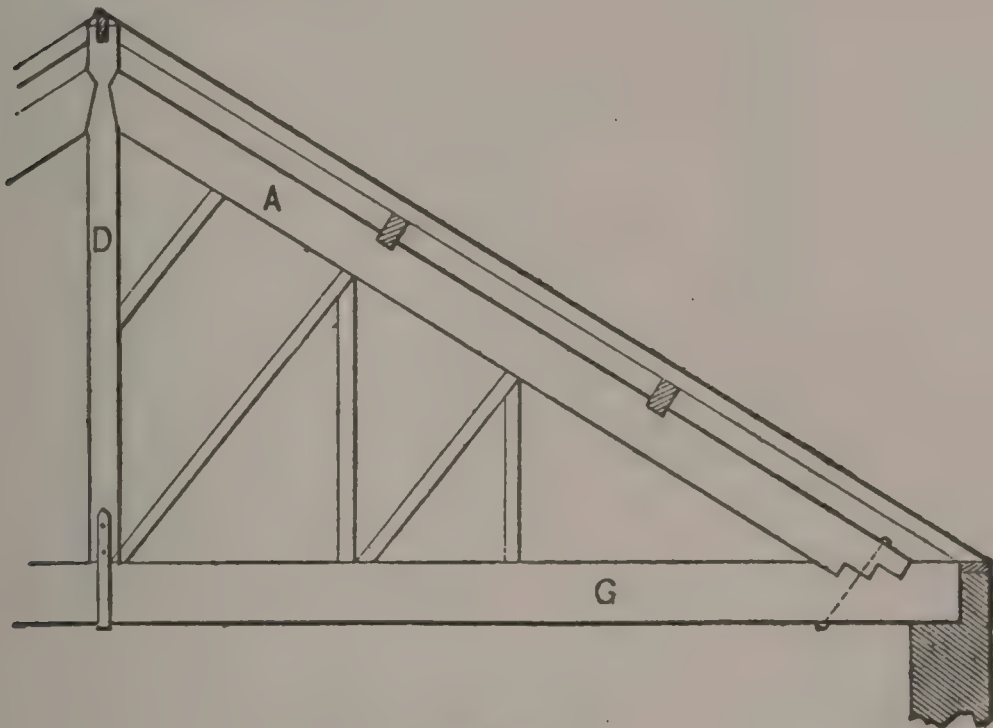


Fig. 331.

I show a very good truss in Fig. 330. This is not a costly roof, but is very strong if well made. D shows the king-post, A the principal, C the cross-beam, B the brace and R a supporting post.

Another king-post truss is shown at Fig. 331. This truss is quite easy to make and easy to understand. A is the principal, D the king-post and C the tie beam. This is suitable for a span of from 30 to 35 feet.

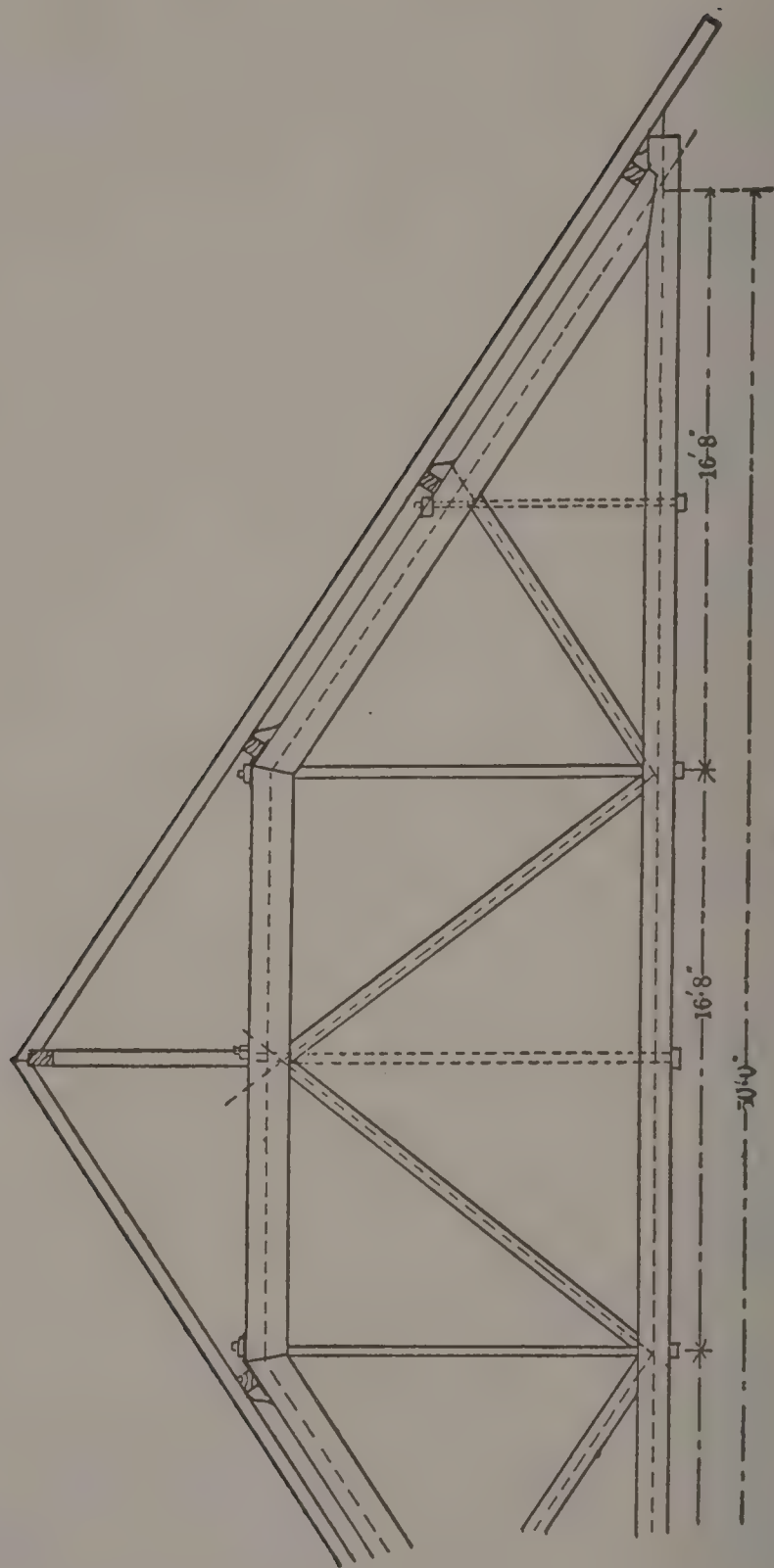


Fig. 332.

Fig. 332 shows a truss that may safely be used where the span does not exceed 50 or 55 feet.

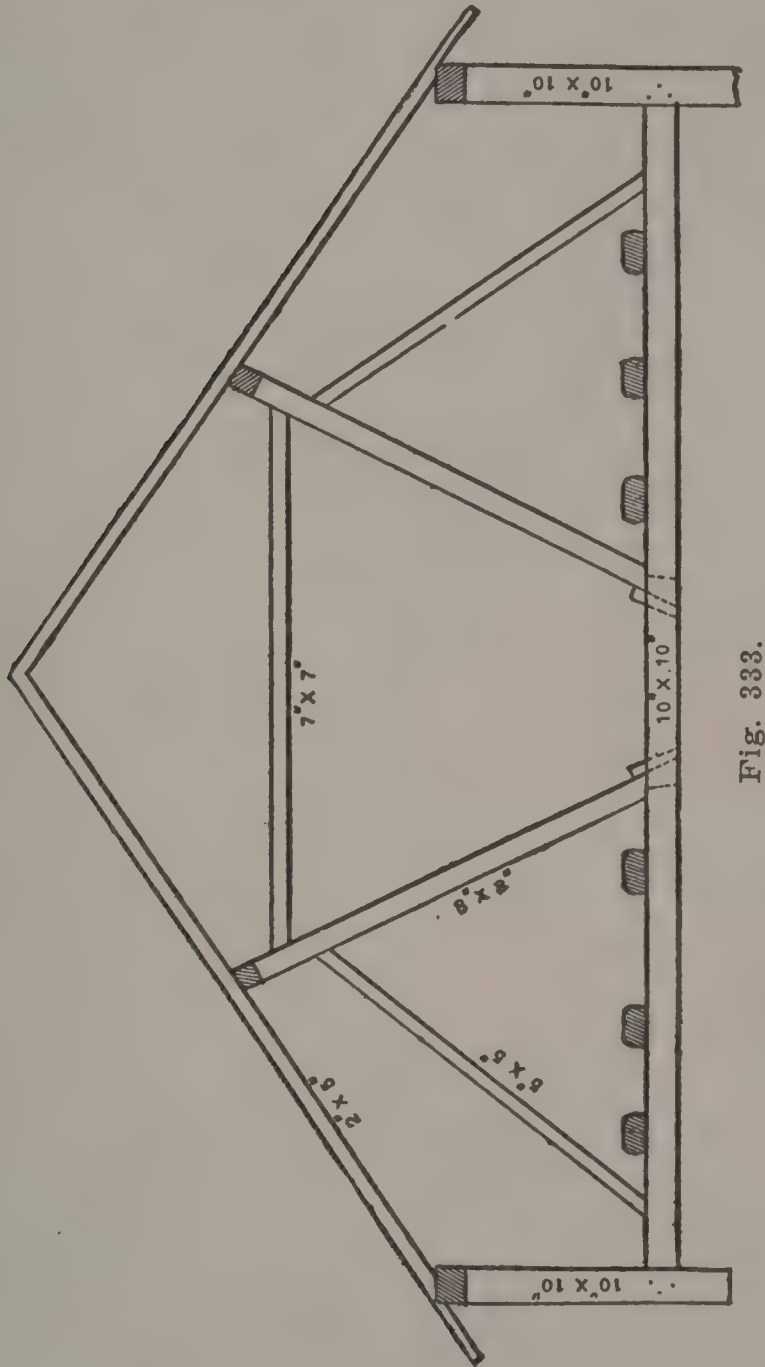


Fig. 333.

The truss shown at Fig. 333 is quite suitable for a light structure of about 30 feet span. The purlin posts are dovetailed into the beam and keyed.



Fig. 334.

This makes it a very solid and stiff roof, and one that may be depended upon to do good service.

Fig. 334 shows a little more than half of a composite roof. The rafters and struts may be made

of pitchpine, and the king-bolt and ties of iron. The roof is to carry ordinary slating, and the trusses will be spaced 10 feet apart. No holes are

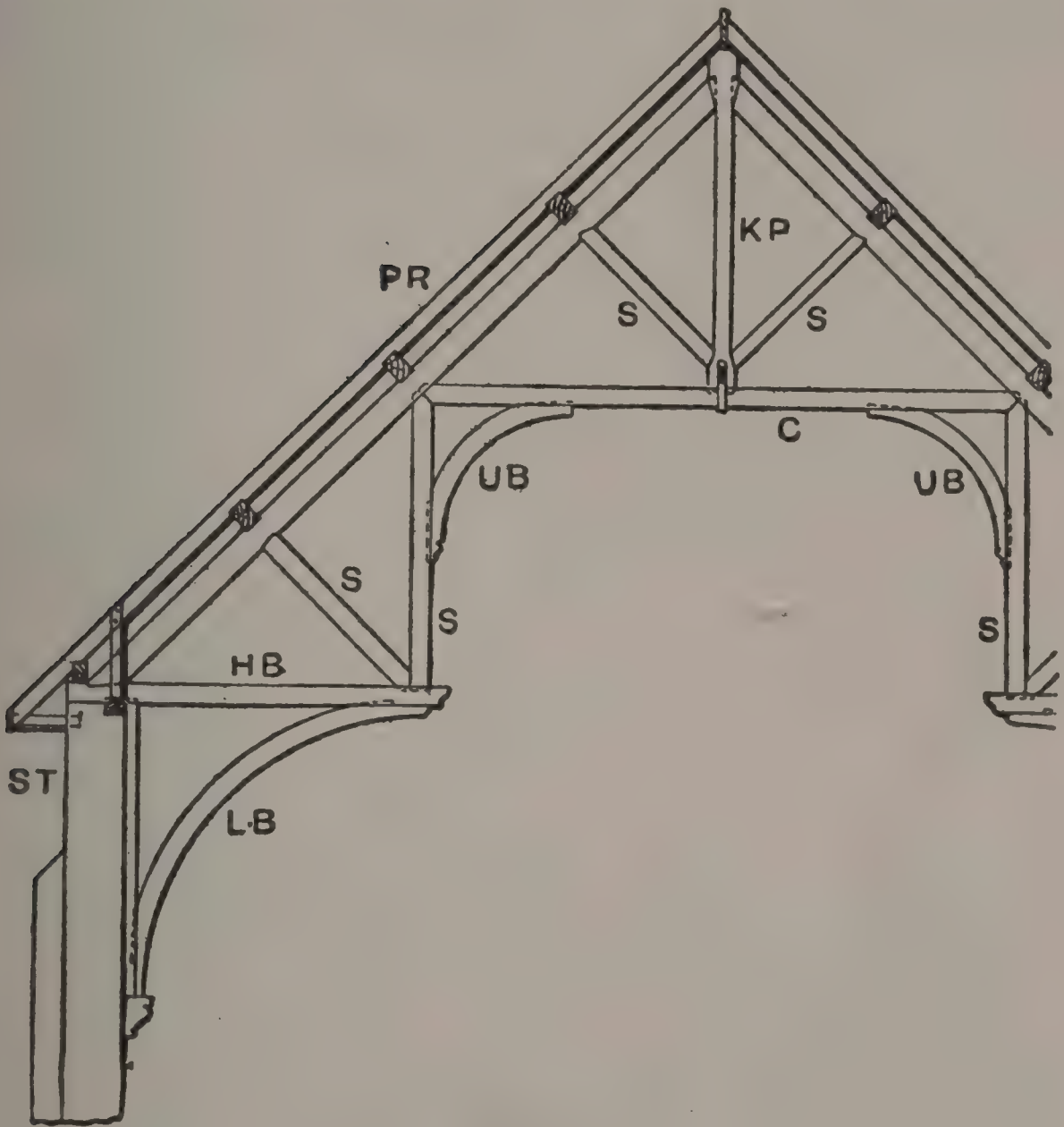


Fig. 335.

bored in struts or rafters; and all the ironwork is such as can be forged from the bar and fitted by a country blacksmith. The foot rests on a stone template.

The hammer-beam truss is a type of open timber roof, and it is shown in Fig. 335, the letters in which have the following references: P R, principal rafters; K P, king-post; C, collar; S S, struts; H B, hammer beam; U B, upper bracket or compass piece; L B, lower bracket; S T, stud. A hammer beam truss exerts considerable thrust, and, therefore, substantial walls and also buttresses must be provided. A thickness of 18 inches is little enough for sound work with a span of 33 feet, but possibly the walls may be somewhat lightened by setting the window openings in 14-in. panels and adding buttresses outside the piers.

Fig. 336 shows the finished hammer beam roof. It may be used in public buildings or for small churches or chapels, the trusses being placed 10 or 12 feet apart. A A A show the finishing on the timbers and B B the drop ornament. The two details, A and B, show the sections on a large scale.

The example shown at Fig. 337 is an illustration of the hammer beam roof over Westminster Hall, London, and is said to be the finest of its kind in the world.

Westminster Hall is sixty-eight feet wide between the walls, and two-hundred and thirty-eight feet long. It is forty-two feet high to the top of the walls, and ninety feet to the ridge of the roof. It is divided into twelve bays, which will accordingly average nineteen feet ten inches each. Con-

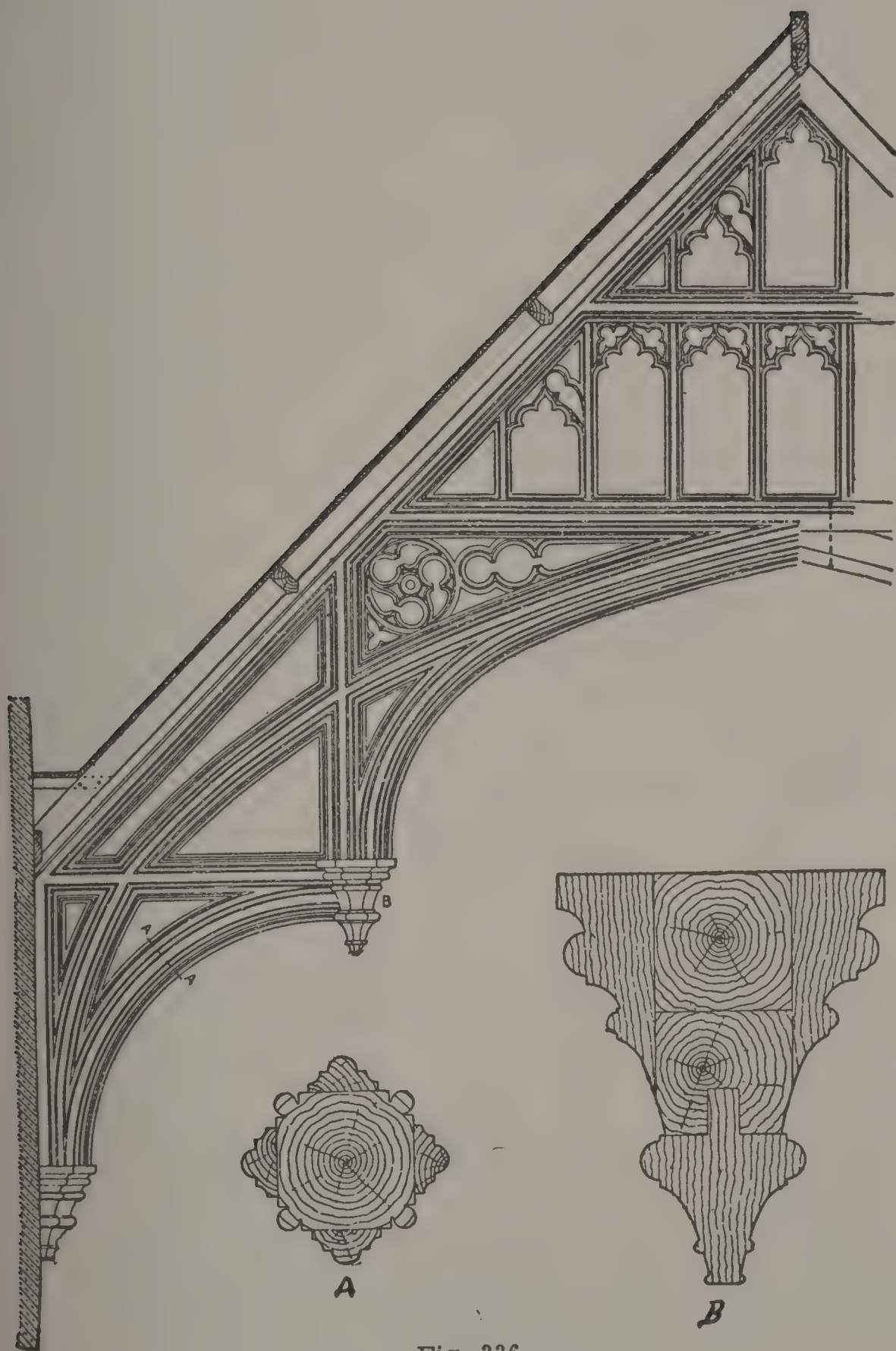


Fig. 336.

sequently each truss has to span sixty-eight feet, and to carry, in addition to its own weight, the weight of slates, timbers, etc., necessary to roof

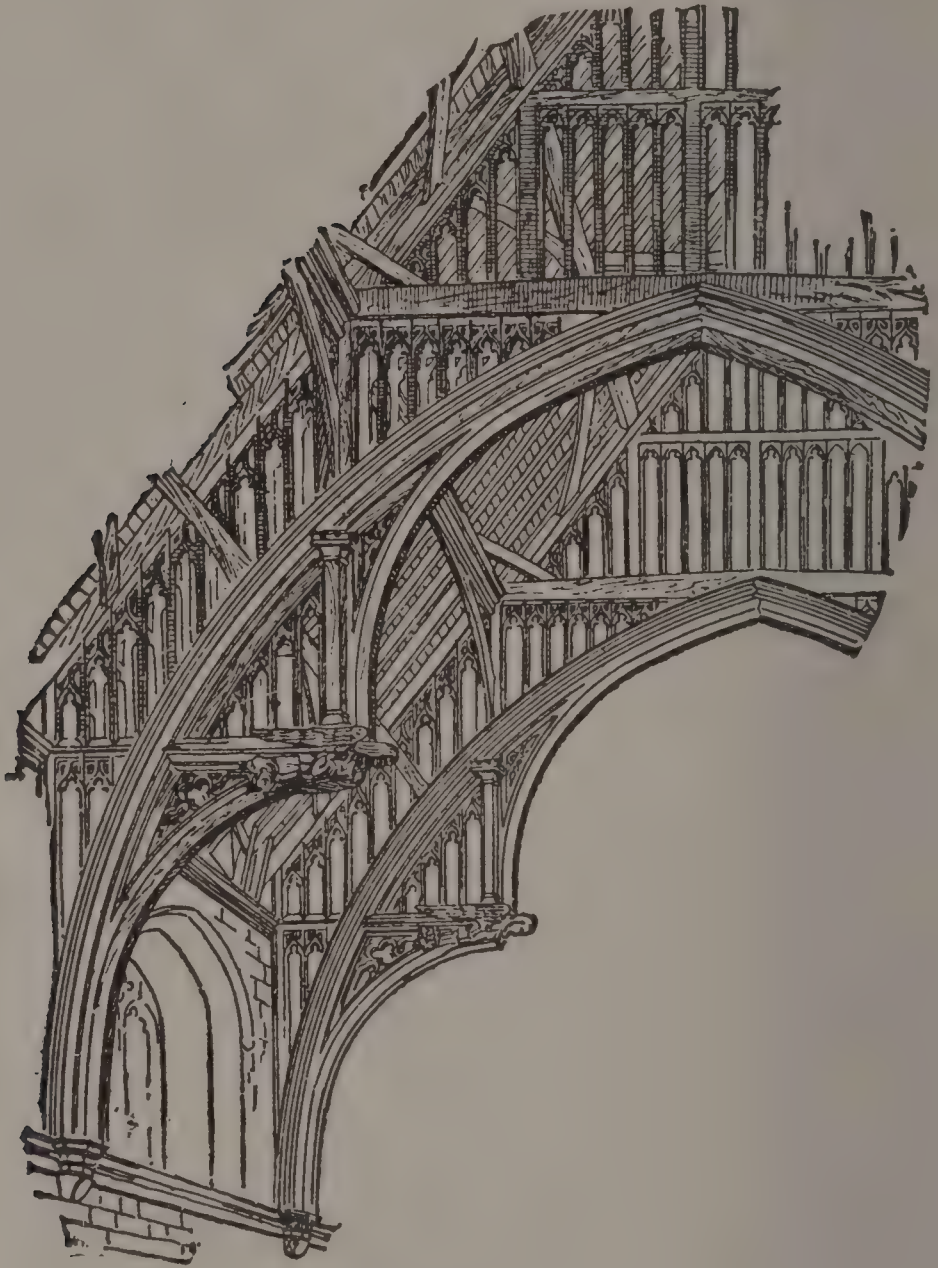


Fig. 337.

in 2,684 feet of floor. The pitch or angle which the slope of the roof makes with the horizon is 52 degrees. The material employed was at one

time believed to be chestnut, but is really English oak. The appearance of the two woods is so much alike that some uncertainty may well be pardoned. The date of the roof is A. D. 1397, so that it is now over five hundred years old. The timber is in good preservation and of large scantling; that is to say, large sectional area. The workmanship throughout is of great beauty and accuracy, and no extensive repair, so far as can be seen, has ever been found necessary. The principal rafter of each truss is of considerable strength. The collar is placed just half way up the rafter. The hammer beams receive the foot of the rafters at their extremity, and each projects rather more than a quarter of the span from the wall, and has its ends beautifully carved with the figure of an angle carrying a crown. A strong post is carried up from the end of the hammer beam to the point where the collar and the principal rafters join. A timber, which may be called a wall-post, rises from a corbel far down the wall, and supports the under side of the hammer beam at the point where it leaves the wall, and a second post vertically above this supports the principal rafter. There is a strong and richly molded rib which acts as a bracket or strut, springing from the corbel just referred to, and framed into the hammer beam, near its free end. A second similar rib, rising from the hammer beam, supports the middle of the collar. All these pieces, except

the principal rafter, are knit together by a magnificent arched rib springing from the corbel from which the lowest carved rib starts, and framed to the hammer beam, the post on the back of that beam, the collar, and both the curved ribs. Above the collar a second collar is introduced, and a post connecting the two is added, while at the middle of the truss, a central post, something like a short king-post occurs. Between all these timbers there is a kind of a filling-in of mullions or small posts, the space between having ornaments at the heads. These, no doubt, perform quite as much the important structural duty of connecting every member of the great framework together, as they do the artistic duty of filling up the great outline with subordinate features which give scale to it, enable its vastness to be appreciated, and bring out the variety of its lines by their contrast with the uniformity of the filling-in.

The usual longitudinal purlins, running from truss to truss, are employed here, and furnish support to the roof rafters. The purlins are themselves supported lengthways from the great trusses by braces. The middle purlin is supported by a beautiful arched rib springing from the post on the hammer beam. The upper purlin has a curved brace springing from the principal rafter. The lower purlin has a curved brace springing from the back of the great curved rib. Below this purlin occur the openings of the roof covering,

which correspond with the great dormer windows, from which the hall receives a considerable portion of its light, but which are said not to have been part of the original design.

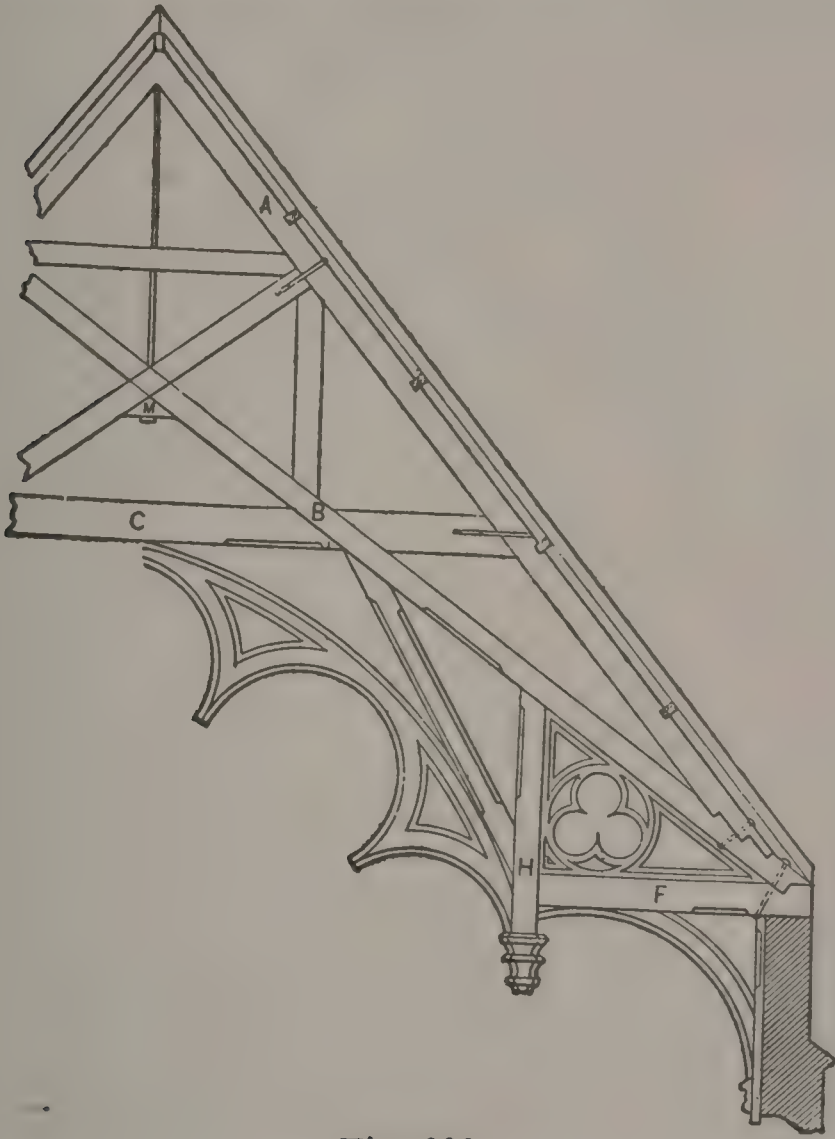


Fig. 338.

The fineness of the workmanship shows that every ornamental part is equally well wrought, and is designed with the greatest skill, and the most honest work possible was expended on its construction.

A hammer beam queen-post truss is shown at Fig. 338. This roof is quite effective, both as to design and construction and would answer admir-

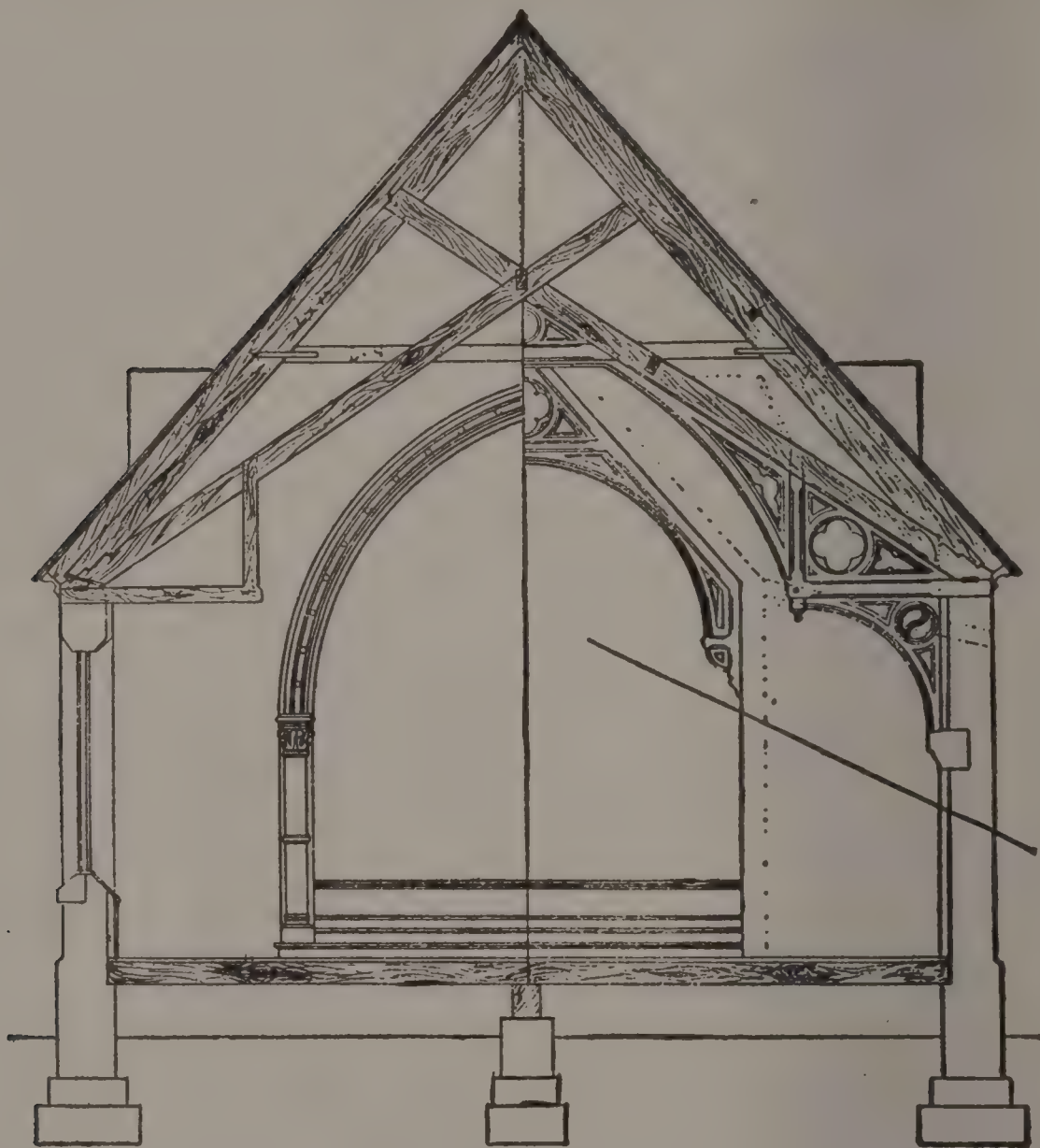


Fig. 339.

ably for any building not more than 45 feet span.

A cheaply formed roof, and one well suited for country churches, is shown at Fig. 339; where the finish also for the Apse of the church is shown.

For small churches in the country, having a seating capacity of from 150 to 400, this kind of a roof and finish is well adapted. While it shows a hammer beam roof, it is simply neither more nor less than a scissor constructed roof.

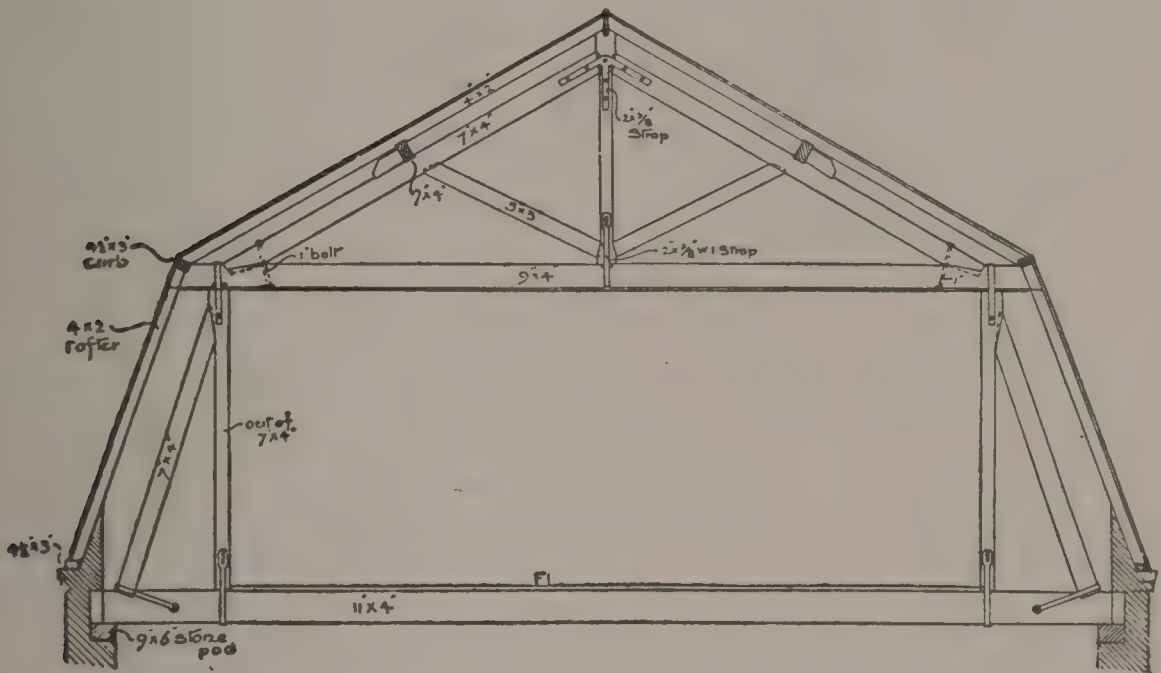


Fig. 340.

The examples given, I take it, are quite sufficient to enable any smart workman to design and construct almost any kind of an ordinary roof of the class shown, so I leave the subject of hammer beam roofs, and, as promised in earlier pages, to show and explain some forms of Mansard, curb or gambrel roofs.

The roof shown in Fig. 340 is a true Mansard, and one of the best designed roofs of the kind. It is suitable for a span of 35 or 40 feet.

The three sketches, A, B, C, shown at 341, give some idea as to the rule governing the designing of Mansard roofs. It will be seen that in each case a semi-circle, drawn from the middle of the base line touches the five main points of the truss. There are cases, however, where the rule cannot always be applied. A noted authority on timber-work objects to this style of roof as being ungraceful in form and causing loss of room as compared

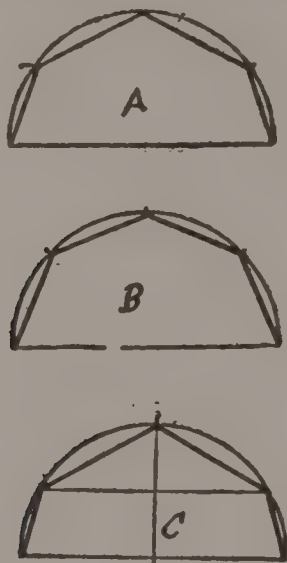


Fig. 341.

with the original roofs of high pitch; and further, on account of the difficulty of freeing the gutters from snow. It is also dangerous on account of its inflammability.

Fig. 342 shows a Mansard roof, having a parapet wall. This roof is suitable for a span of 30 feet, and owing to the setback from the coping on the parapet wall, has a good appearance.

For a span of from 16 to 20 feet, the roof shown at Fig. 343 would answer very well and prove quite economical, both as to material and labor.

A self-supporting curb roof is shown at Fig. 344, which is intended for a long span extending 50 feet or more. This shows how a flat curb roof may be constructed. For a less span, a king-post

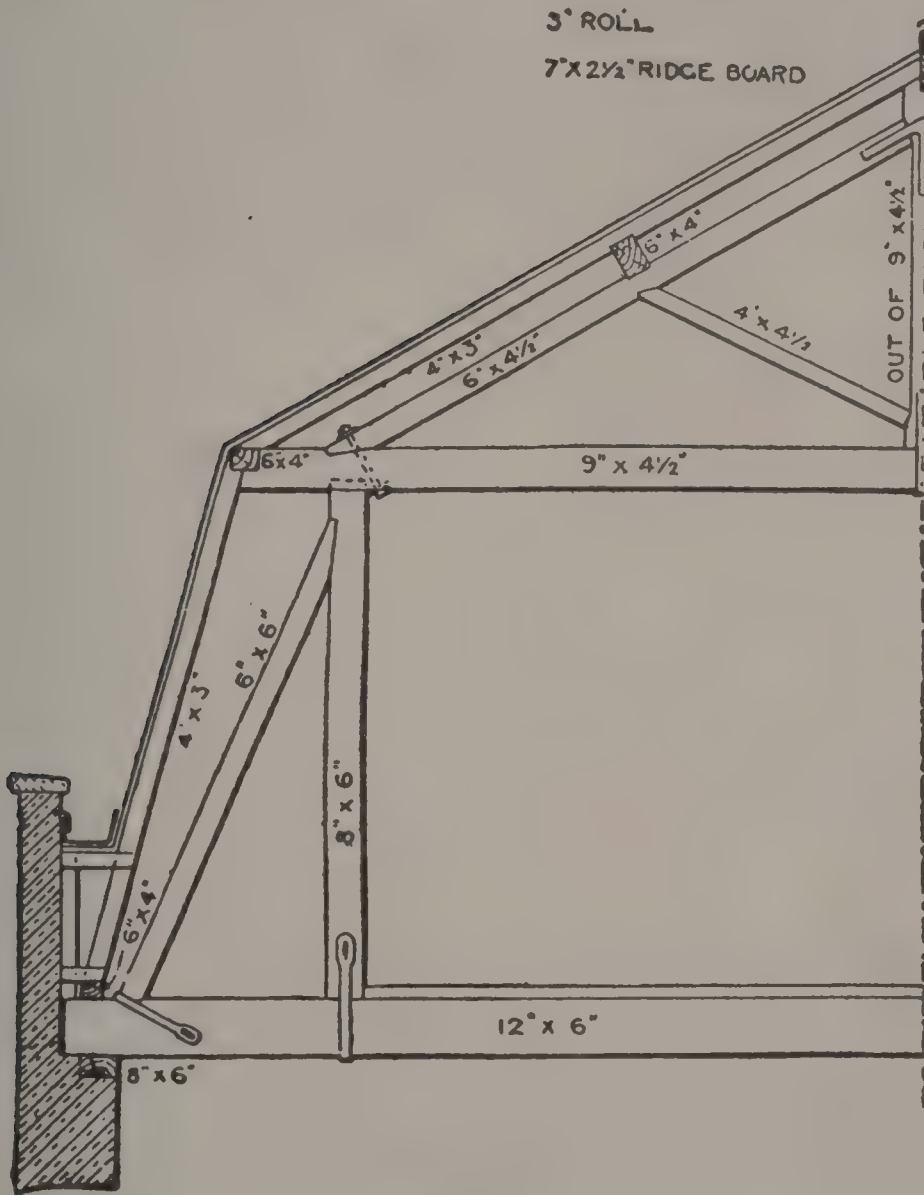


Fig. 342.

may be used and the two queen-posts left out. Braces could run from the foot of the king-post to the break in the principals at B and shaped with iron as shown. As roller skating rinks are

again coming in use, this truss might in some cases be used for covering same. However, I now

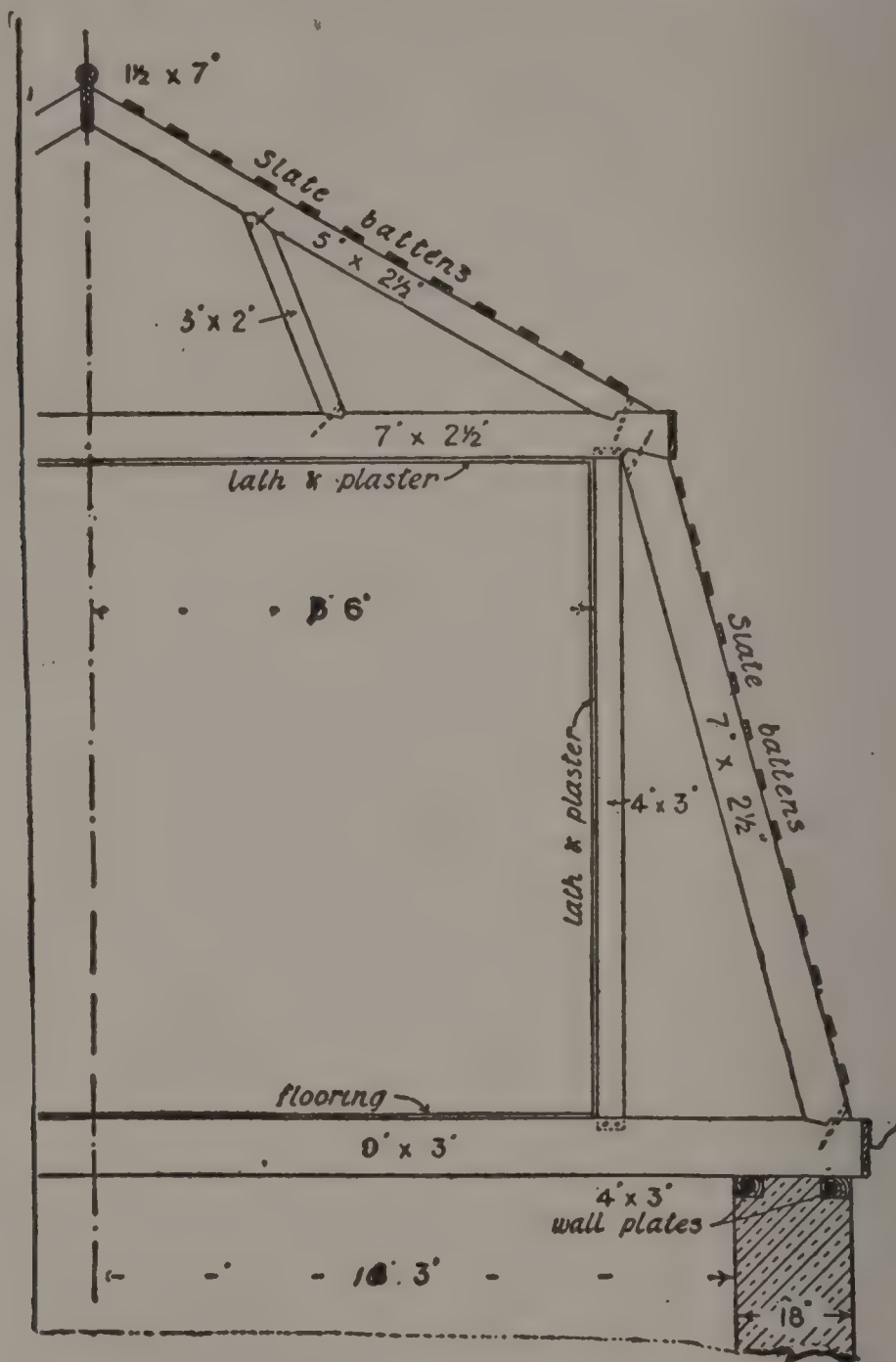


Fig. 343.

leave Mansard roofs, and will give an example or two of roofs suitable for skating rinks or for similar purposes.

The roof shown at Fig. 345 is one that has been employed over a rink having a floor space of 60 x 150 feet, and dressing rooms and galleries on the sides. The trusses are placed 14 feet apart. The purlins are 2 x 6, and are set two feet apart. The rafters over the galleries are 2 x 4 inches, set 2 feet apart, and at the upper ends are spiked into the lower purlin which lies at the foot of the trusses. The tie-beam is spliced in the middle by bolting a 2 x 8 timber on each side. The braces

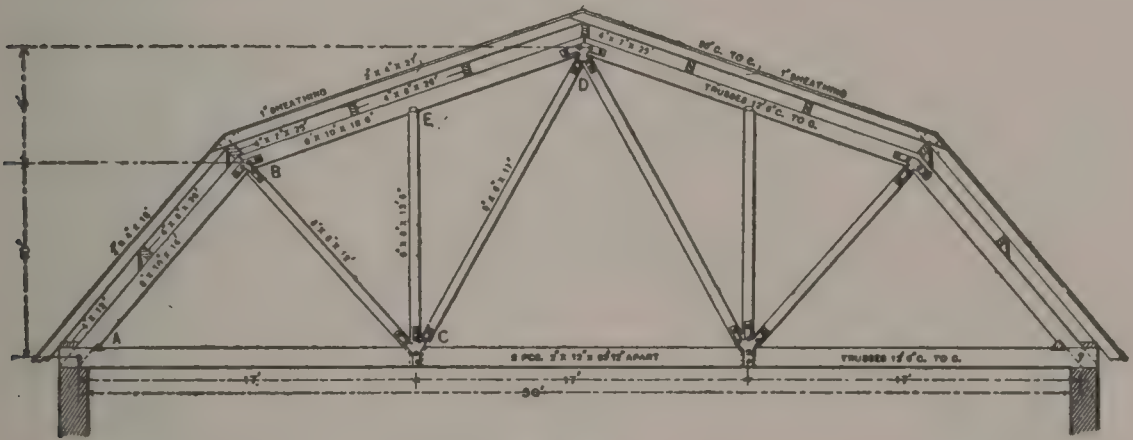


Fig. 344.

at the foot of the truss are spiked on both sides. The roof is sheeted with $\frac{7}{8}$ -inch pine boards, nailed on to the purlins parallel with the rafters and covered with No. 26 iron roofing. The dimensions of the timbers are marked on the sketch.

A roof more pretentious is shown at Fig. 346, which has been in use for some time. It is a very economical structure and not difficult to construct: The building is 80 x 172 feet, outside measurements, affording a skating surface of 64 x 154 feet.

The sills are of solid timber, 8 x 8 inches, Norway pine. The foundation consists of stone piers 14 x 14 inches, 24 inches deep, and 18 inches in the ground. These are in eight rows, extending the

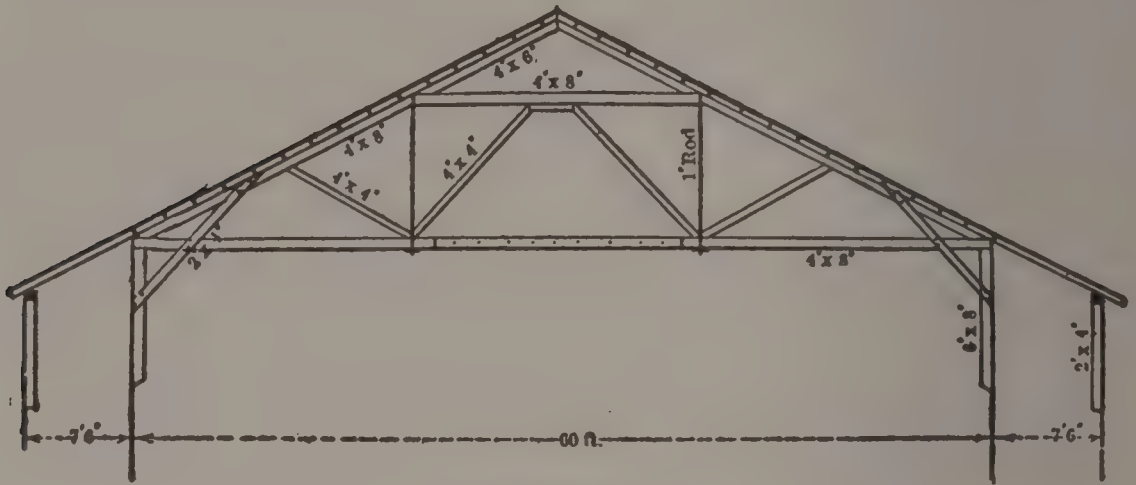


Fig. 345.

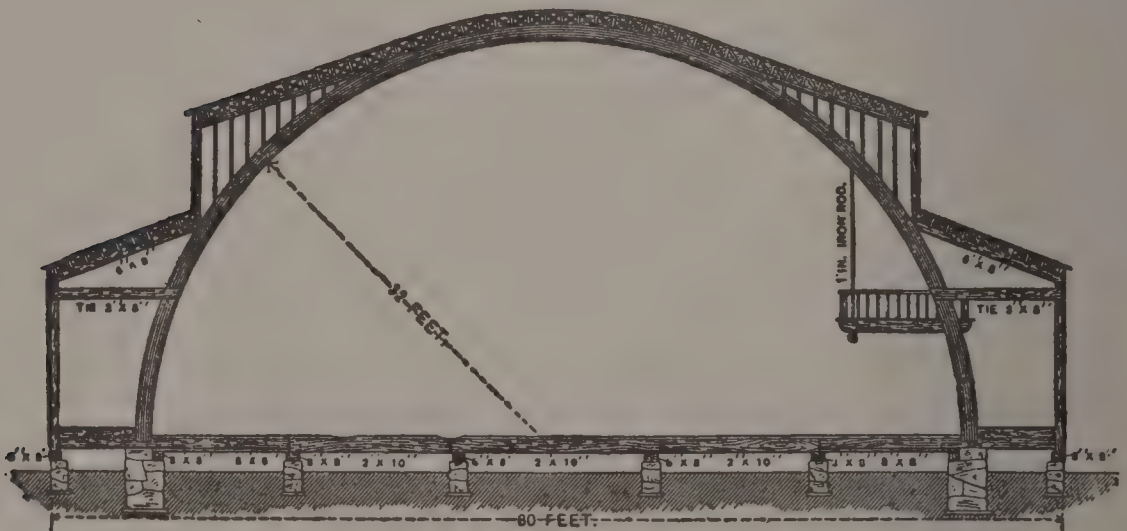


Fig. 346.

entire length of the building, 6 feet apart. The piers under the arches are 24 x 24 inches in size, and are 36 inches deep. The joists of the skating floor are 2 x 10 inches in size, placed 16 inches

between centers. They are 14 feet long, and lapped together and thoroughly spiked. The cords running from arch to arch on each side of the building the entire length to support the roof are of 4 x 10 timber properly gained into the principal rafters. From each arch to the outside studding a 2 x 8 inch tie is spiked. The building is covered with drop siding, from 6 inch C strips. The roof projects 6 inches, and is finished with a plain barge board and facia. The skating surface is covered with an under floor of common pine boards, surfaced and laid diagonally. These are nailed to the joists and are covered with felt. The skating floor is of dry, matched, clear maple flooring, $\frac{7}{8}$ inch thick and $2\frac{1}{2}$ inches wide, blind-nailed on bearings and smooth-planed and sand-papered after laying. The maple floor was laid with mitered joints at the corners, and with a rectangular space 14 feet wide in the center. The floors in the galleries and of the platforms are of common pine matched. The roof is hipped back from the end walls, which are 26 feet 9 inches high to the first arch. The entire roof is covered with cement roofing. The building has nine arches, located as shown on plans. These are $33\frac{1}{2}$ feet high and measure in section 10 x 15 inches. The arches are built of 1 x 10 inch boards, planed and jointed, and fastened together with 10d. and 20d. nails. The feet of the arches are gained 2 inches into

the cross-sills. The opposite cross-sills are connected together by 2 x 10 tie-joists.

A lattice truss may often be used over short spans, or even for greater spans if the timbers and lattice strips are made in proportion. The truss shown at Fig. 347 will do nicely for a 27 feet span. The lattice trusses may have a rise of 3 feet and radius of 36 feet and be placed 7 feet apart. The top and bottom members may be made up by



Fig. 347.



Fig. 348.

two separate thicknesses of 7-in. by 11¼-in. breaking joint. The lattice bars may be about 2½ in., 1¼ in. and 3 feet apart, radiating as shown. The purlins should be 3 in. by 2 in. at 3 feet centers, and covered with ⅝-in. boarding and tarred felt. Cross bracing 4½ in. by ¾ in. between trusses as shown. The following is the rule for obtaining the radius of roof principals of the wood lattice pattern. If the rise be made one-tenth of the span, the radius will be thirteen-tenths of the span.

Thus, 85-ft. span equals 8-ft. 6-in. rise and 110-ft. 6-in. radius, but this would be a large roof for such a system. The lattices may be arranged so that center lines through the top and bottom apices are radial to the external curve, as shown in Fig. 340, or the lattices themselves may be drawn towards two points equal to span apart and half span below tie-beam, as shown in Fig. 349. The former has the better appearance, but the

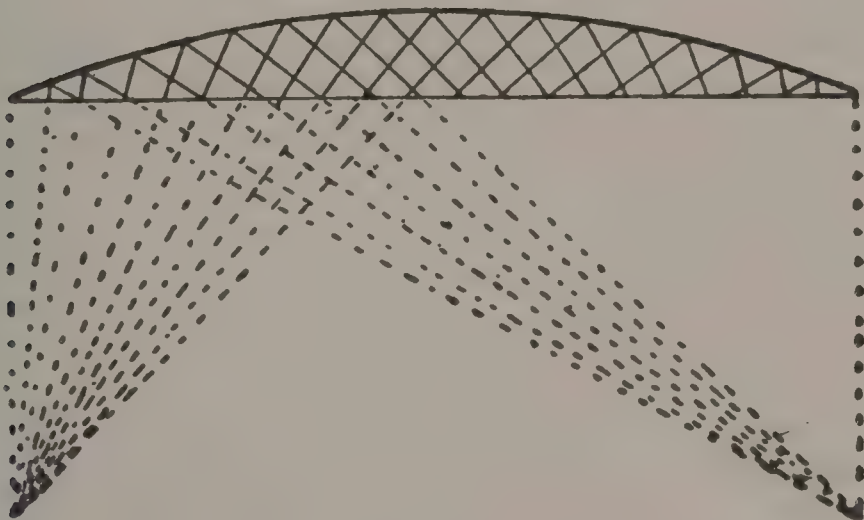


Fig. 349.

latter has more crossings where the lattices can be secured to each other to help in stiffening them. Galvanized corrugated iron forms a good covering for these roofs.

Sometimes this kind of a truss is used in bridge building, but since steel has become such a factor in structural work, the lattice bridge or roof is very seldom employed.

Wooden spires, turrets and towers of various kinds are still erected in many parts of the country, and a book of this kind would scarcely be complete if these framings were not mentioned: Fig. 350 shows the construction of a spire 85 feet high above the tie-beam, or cross-timber of the roof. This is framed square as far as the top of the second section, above which it is octagonal. It will be found most convenient to frame and raise the square portion first; then to frame the octagonal portion, or spire proper, before raising it; in the first place letting the feet of the 8 hip rafters of the spire, each of which is 48 feet long, rest upon the tie-beam and joists of the main building. The top of the spire can, in that situation, be conveniently finished and painted, after which it may be raised half way to its place, when the lower portion can be finished as far down as the top of the third section. The spire should then be raised and bolted to its place, by bolts at the top of the second section at AB, and also at the feet of the hip rafters at CD. The third section can then be built around the base of the spire proper; or the spire can be finished, as such, to the top of the second sections, dispensing with the third, just as the taste or ability of the parties shall determine.

No. 2 presents a horizontal view of the top of the first section.

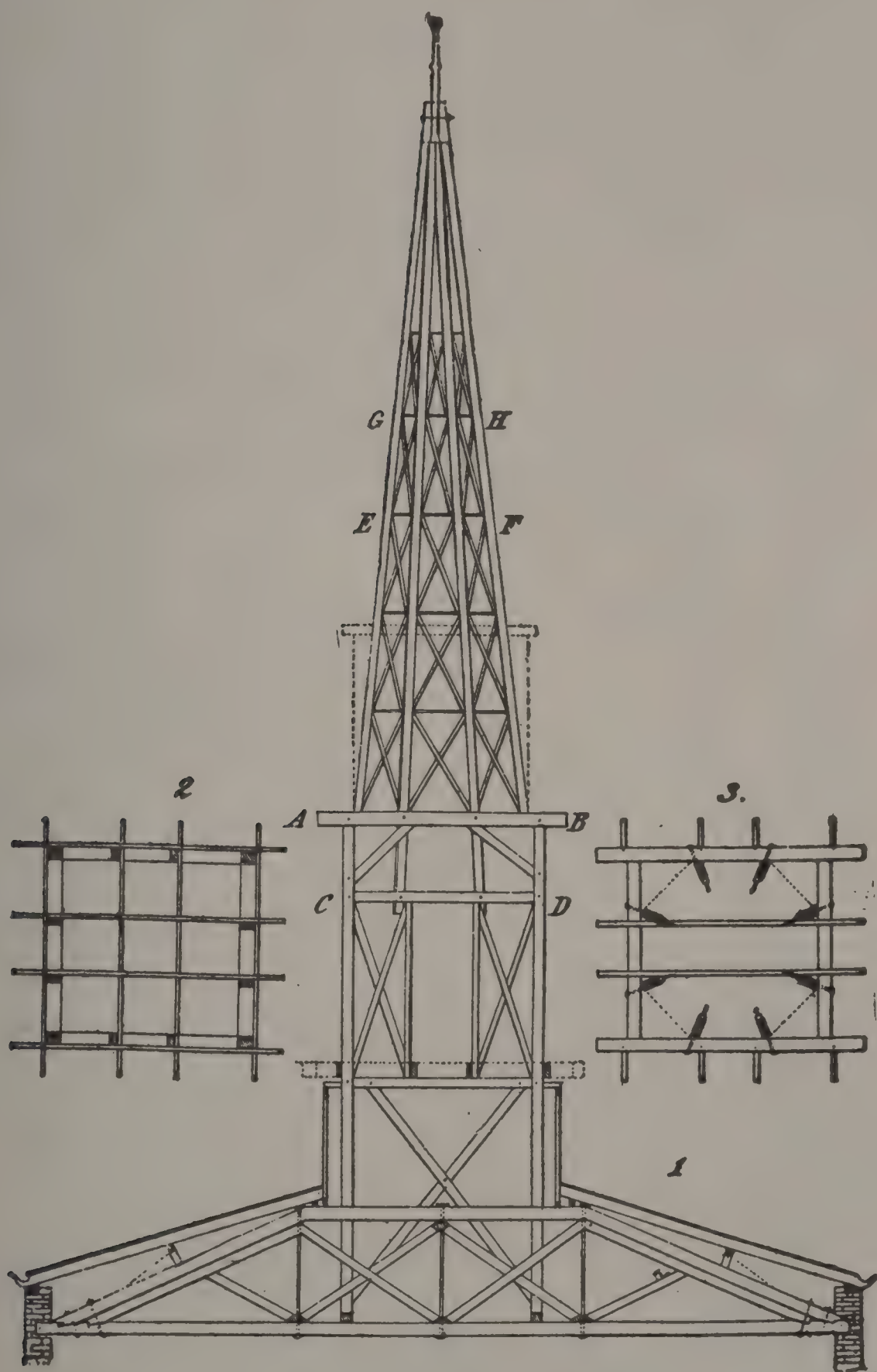


Fig. 350.

No. 3 is a horizontal view of the top of the second section, after the spire is bolted to its place.

The lateral braces in the spire are halved together at their intersection with each other, and beveled and spiked to the hip rafters at the ends. These braces may be dispensed with on a low spire.

A conical finish can be given to the spire above the sections, by making the outside edges of the cross-timbers circular.

The bevels of the hip rafters are obtained in the usual manner for octagonal roofs, as described in other pages.

In most cases the side of an octagon is given as the basis of calculation in finding the width and other dimensions; but in spires like this, where the lower portion is square, we are required to find the side from a given width. The second section in this steeple, within which the octagonal spire is to be bolted, is supposed to be 12 feet square outside; and the posts being 8 inches square, the width of the octagon at the top of this section, as represented in No. 3, is 10 feet 8 inches, and its side is 4 feet 5.02 inches.

The side of any other octagon may be found from this by proportion, since all regular octagons are similar figures, and their sides are to each other as their widths, and conversely their widths are to each other as their sides.

Another example of high spire is shown at Fig.

351, in a completed state. This is taken from "Architecture and Building," published by Wm. Cumstock, New York, and is a good example of a tall slim spire.

This spire is 111 feet 6 inches high above the plate, and the latter is 69 feet above the sidewalk. The total height from sidewalk to top of finial is 190 feet. The tower is of stone, 19 feet square, with buttresses as shown. The spire is a true octagon in section, and each of the eight sides is braced in the same way, with the exception of the lower panel, in which the bracing is omitted on four sides back of the dormers. Besides the bracing shown in Fig. 352 the spire was braced across horizontally at each purlin to prevent distortion in the octagon. At the top the eight hips are cut against a ten-inch octagon pole and bolted to it in pairs. This pole is 32 feet long and is secured at the bottom by bolting to 4 x 6 cross-pieces, which are securely spiked to the hips. In the center of this pole is a 1½-inch iron rod, which forms the center of the wrought iron finial.

The lower end of each hip is secured to the masonry by 1½-inch bolts, 6 feet long. The plate extends the full length of each side of the tower and is bolted together and to the walls at the corners. A short piece of 6 x 6 timber is placed on top of the plate, across the corners, to receive the rafters on the corner sides of the octagon. The braces and purlins are set in 4 inches from



Fig. 351.

the outer face of the hips to allow for placing 2 x 4 jack rafters outside of them. These rafters are not shown in the figure; they were placed up and down, 16 inches on centers, and spiked to the purlins and braces.

As may be seen from Fig. 351, the top of the tower is rather light for supporting such a high framework, and is moreover weakened by large openings in each side. It was, therefore, determined to transfer the thrust due to the wind pressure on the spire to the corner of the tower at a point just below the sill of the large openings. The manner in which this was done is shown by Fig. 353, which is a diagonal section through top of tower. The purlins C, C, Fig. 351, were made 6 x 10 inches, set on edge and securely bolted to the hips. From the center of these purlins on each of the four corner sides 6 x 10-inch posts were carried down into the tower, as shown in Fig. 353. These posts were secured at the bottom to 10 x 10-inch timbers, which were placed across the tower diagonally and solidly built into the corners. The bracing shown was used merely to prevent the posts from bucking. Only one pair of posts is shown in the figure. The effect of these posts is to transmit the entire wind pressure on the leeward side of the tower from the purlins C, C to the corners of the tower at the bottom of the posts. The tension on the windward side is resisted by the hip rafters and the bolts by which

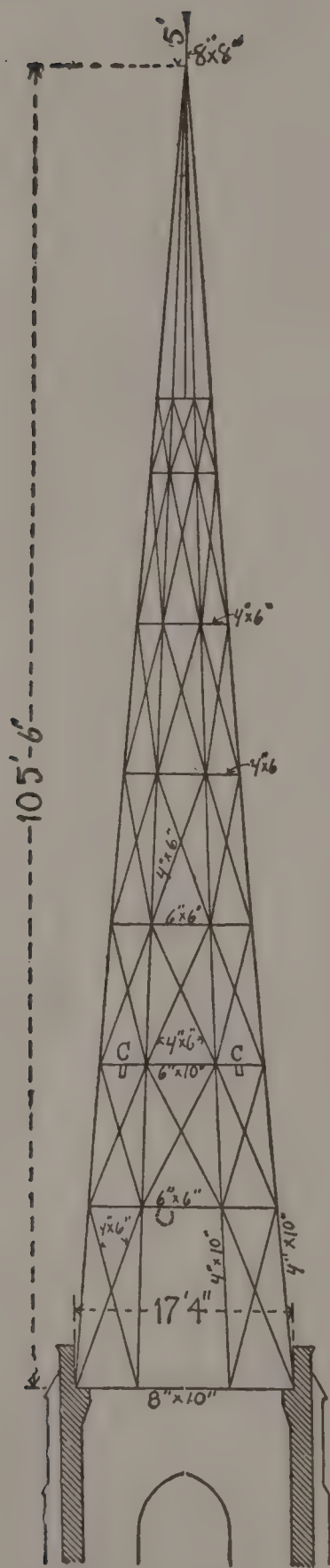


Fig. 352.

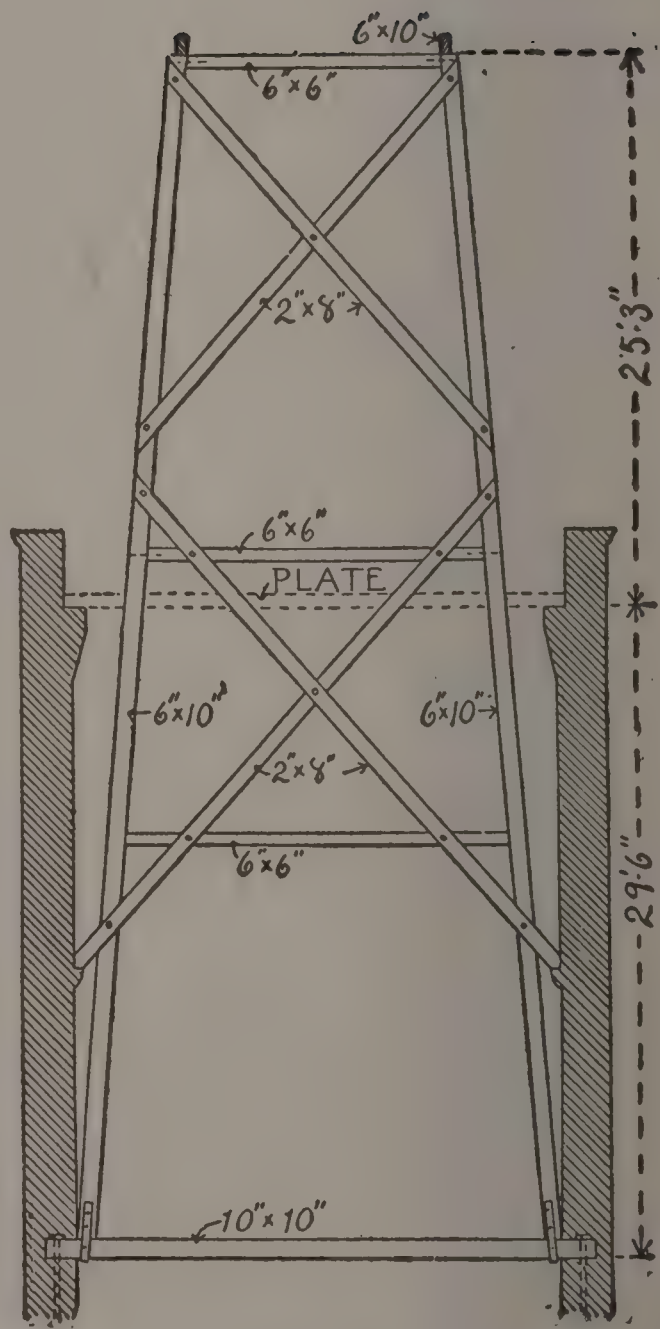


Fig. 353.

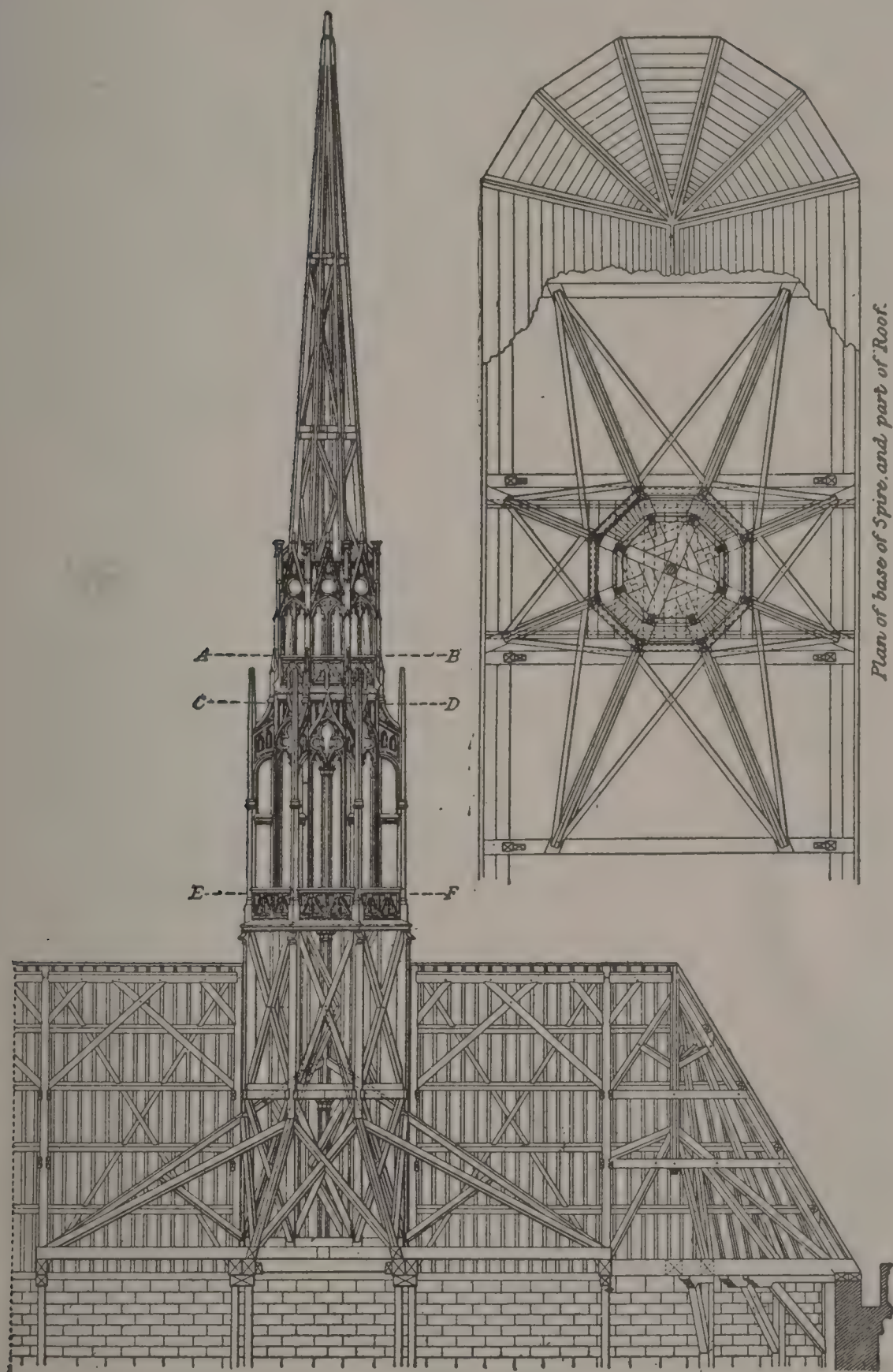
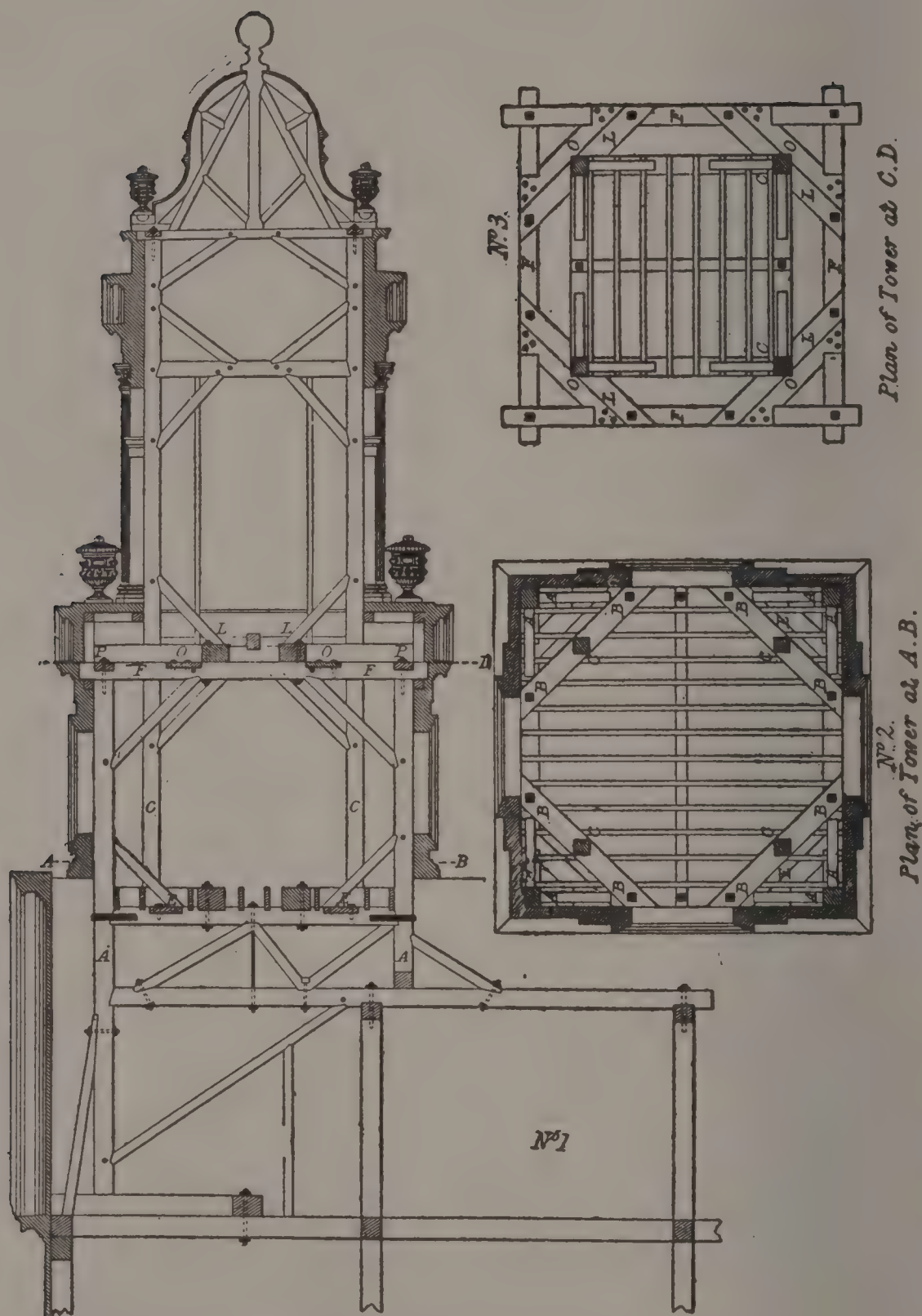


Fig. 354.



*Elevation of Framing of Tower of the Town hall,
Milford, Mass.*

Fig. 355.

they are anchored to the wall. This spire has stood for five years, and no cracks have as yet appeared in the tower, although the $1\frac{1}{2}$ -inch rod in the wrought iron finial was slightly bent during a severe gale.

The elevation and plans of the framework of a French spire are shown at Fig. 354, the whole is so plain that a further description of it is unnecessary. This is a fine specimen of French timber work and is worthy of study.

The tower shown at Fig. 355 is an old example of New England timber work—the plans are shown at No. 2 and No. 3. The illustration shows clearly enough the construction as to render description unnecessary.

Fig. 356 shows the elevation of a round tower, and Fig. 357 the plan and framework of same. As this example is somewhat different to the foregoing ones, some explanations are required to make the drawings clear and understandable.

Referring to Fig. 357, let it be supposed that 1, 2, 3, 4, etc., represent the plan of the tower and M P its rise. Strike the plan full size or to a scale as may be most convenient.

For laying out the plan or line of the plate, draw lines for the rafters, as 15, 26, 37 and 48. Directly above the plan draw the elevation, beginning with a straight line, as K O, to represent the plate, and make it the same length as 37 of the plan. Raise the center line M P the height of

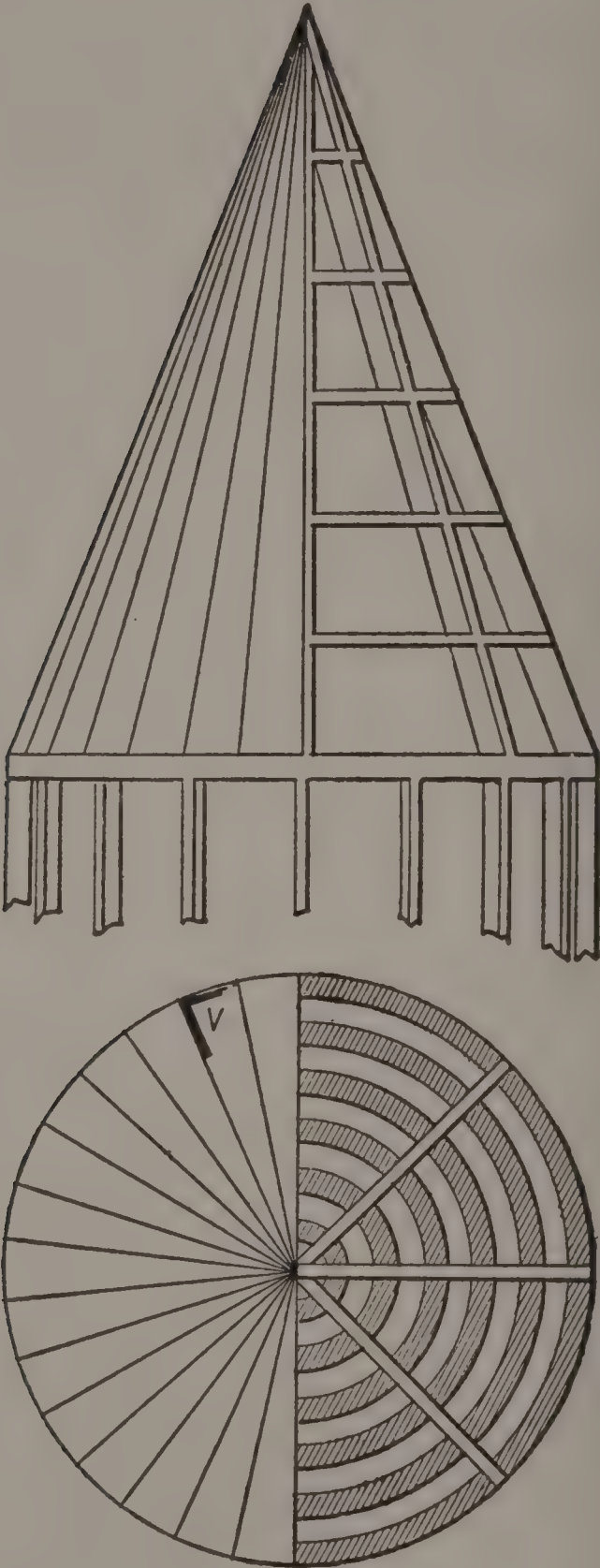


Fig. 356.

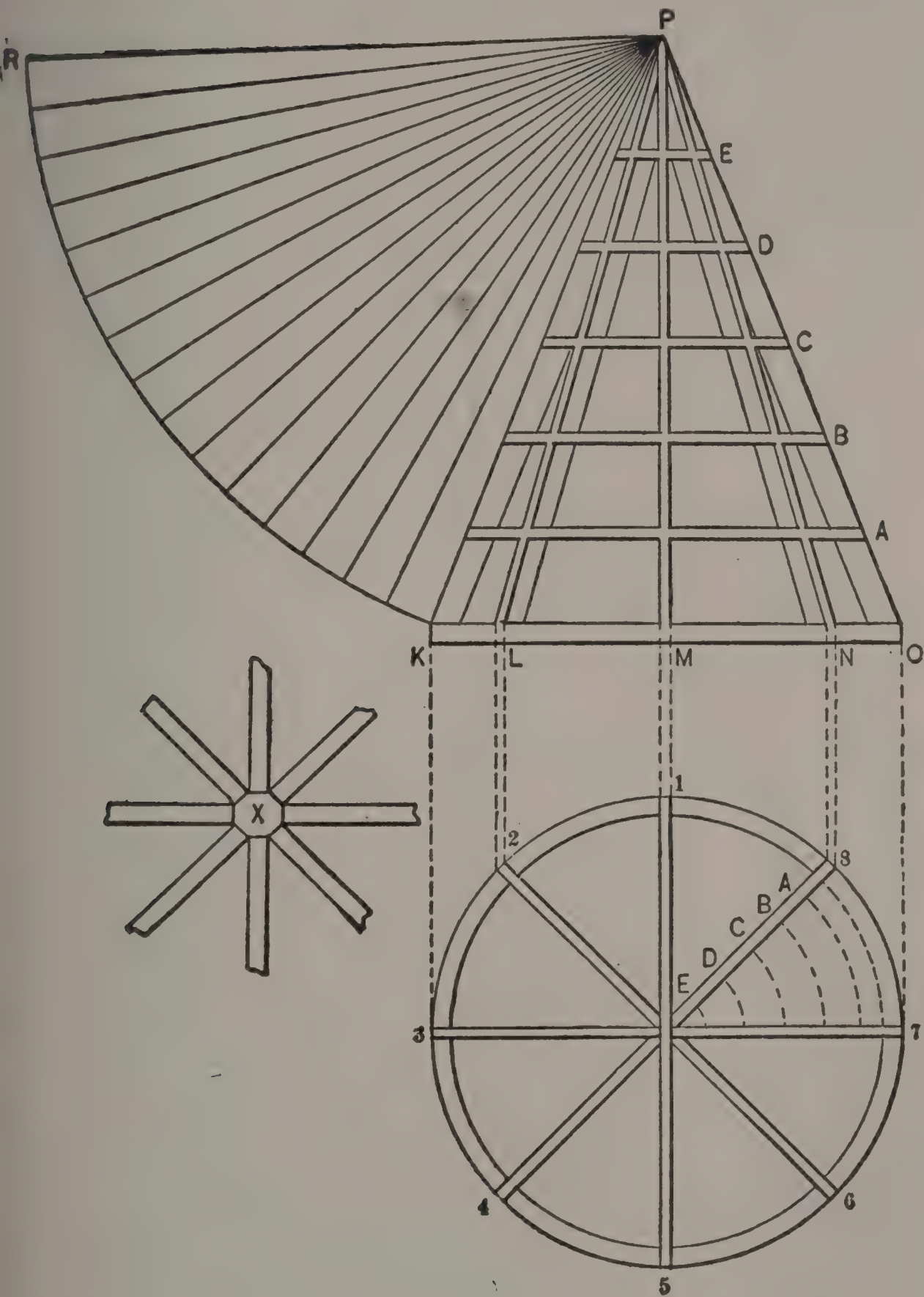


Fig. 357.

the tower and join O P and K P, which will be the lengths for all the rafters. To obtain the horizontal pieces A, B, C, D, etc., to which the sheeting is nailed in the manner represented in Figs. 1 and 2, proceed as follows: Divide the height into as many parts as desired—in this case six, which requires five horizontal pieces between each pair of rafters. The exact length and cut will be given by striking out the sweeps shown on the plan. A better idea of the manner in which the roof is constructed will be gained from inspection of Fig. 356, which shows each stud, plate, rafter and sweep in proper position, also the covering boards nailed on half way round. To obtain the exact shape, length and bevel for the covering boards the following method is employed: Take P of Fig. 357 as a center, with K as a radius, and describe the arc K R. The distance from K to R represents one-half of the circle or plan of the tower. The distance from K to R may be divided into as many parts as desired. In this case it is divided into fifteen parts, thus giving 15 tapering boards, which cover one-half the tower. Lines drawn from P to the arc K R are the inside lines of the joints. To obtain the bevel of the jointed edges of the boards set a bevel at V, as shown in Fig. 356. In the plan shown the rafters are cut so as to fit against a block, X, shaped to suit the plan of the roof. This manner of butting the rafters against the block X

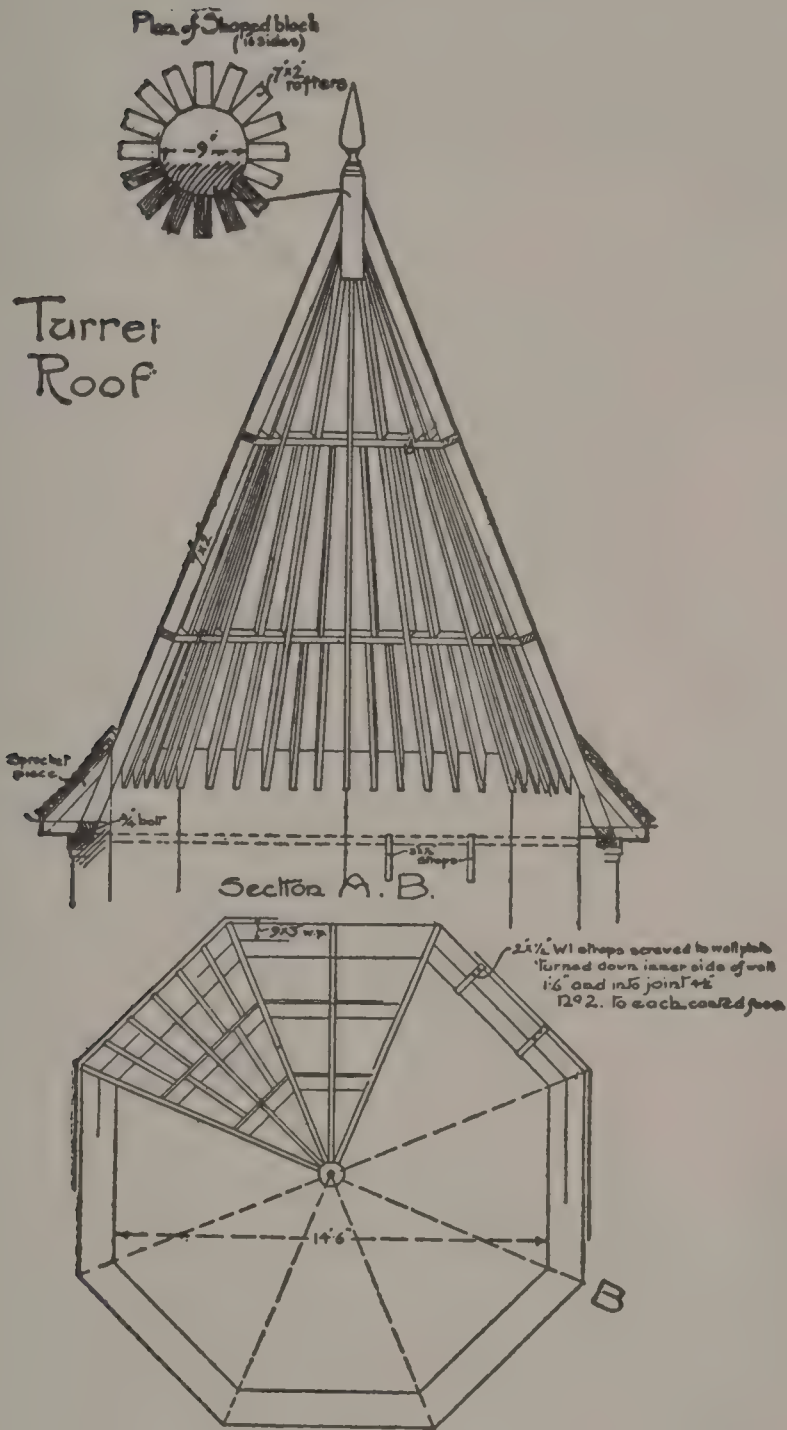


Fig. 358.

saves the time and labor of cutting the side bevels on the rafters which would be necessary if the block was not employed.

A turret roof is shown at Fig. 358, and explana-

tions are given on the drawing in connection with the framing and construction of the whole work, all of which should be readily understood by the workman.

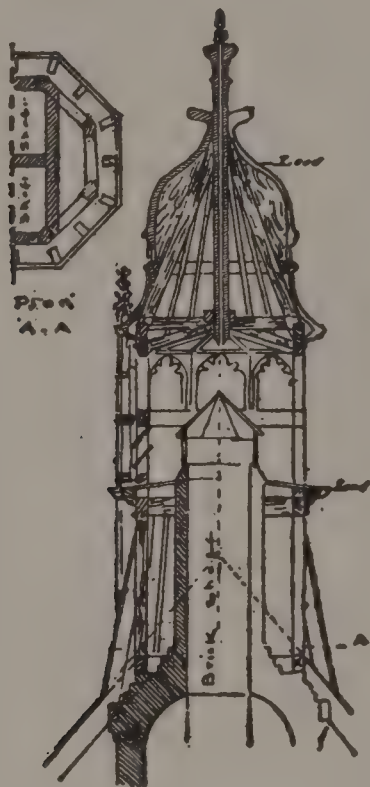


Fig. 359.

I show two examples of towers in Figs. 359 and 360, and as the timbers shown are figured it would be waste of space to lengthen our description.

With these examples I conclude on spires, towers and turrets, and will now endeavor to show and describe some examples of timber barns, and work of a similar kind. The illustrations shown are sufficiently clear to render lengthy description unnecessary. The sketch shown at Fig. 361 is intended to represent the end of a barn about 55 feet

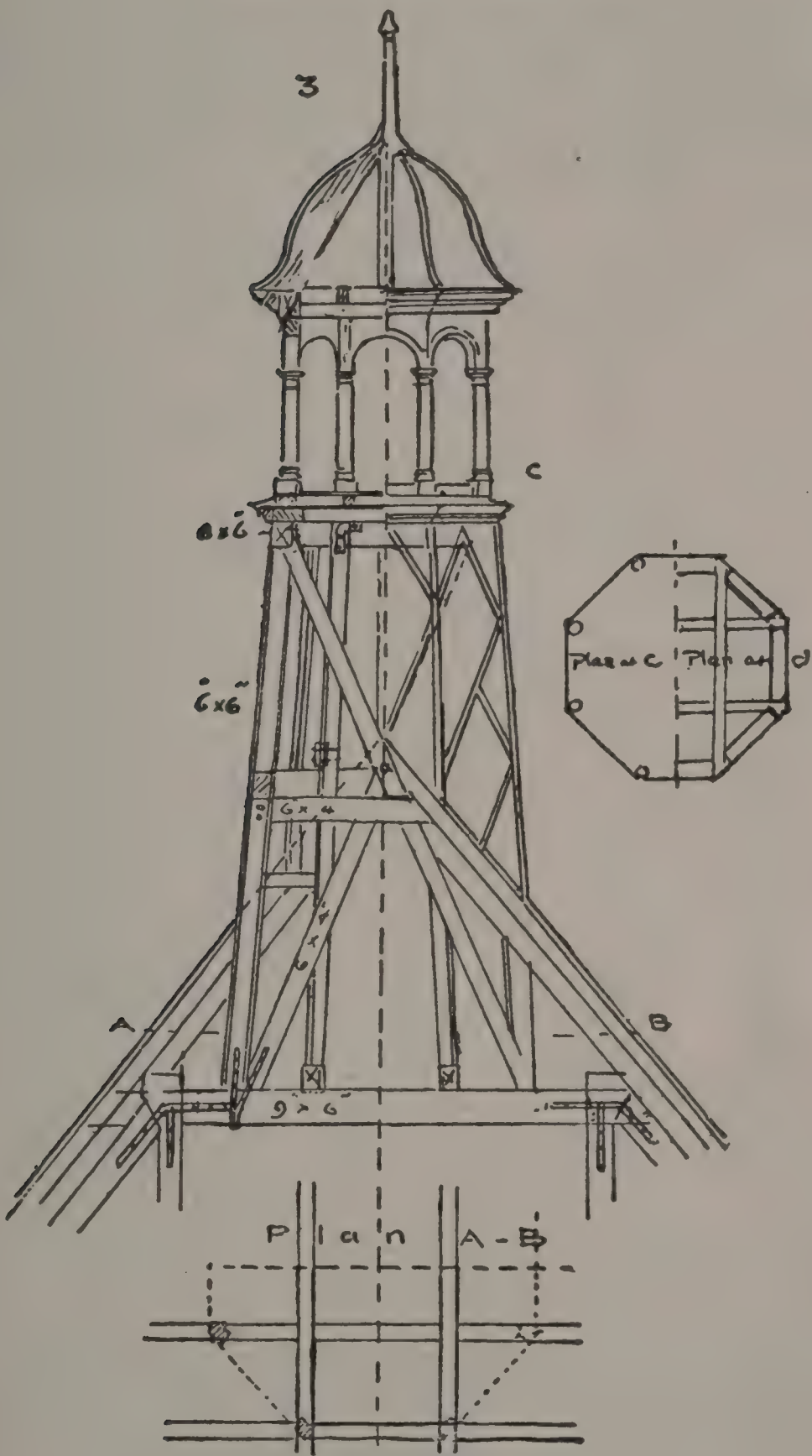


Fig. 360.

wide. The open space under the main floor may be left as a shelter for cattle, or it may be built in an excavation in a bank, forming what is known as a "bank barn."

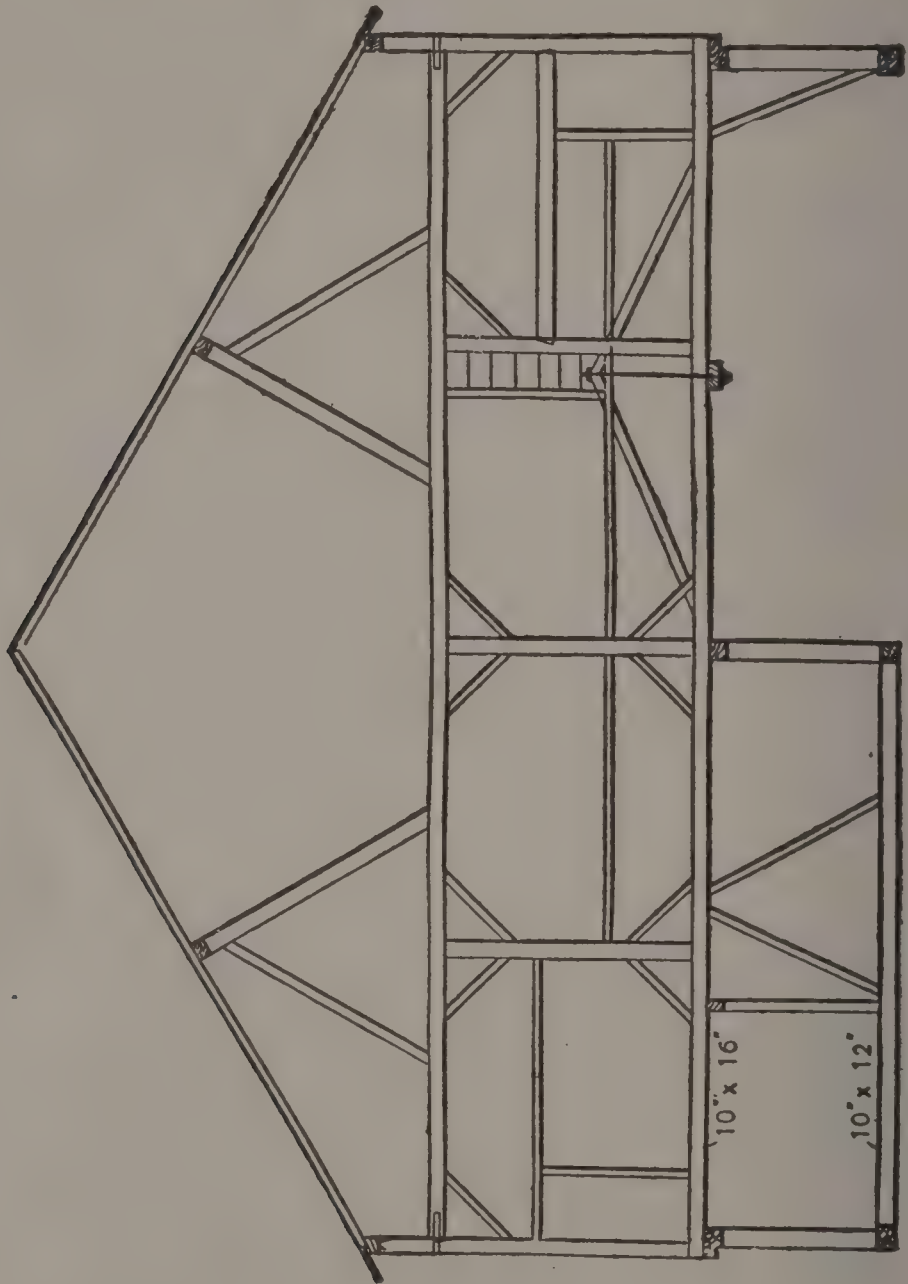


Fig. 362 shows another sketch of barn which is slightly different from the previous one. This may be used as a bank barn or otherwise.

The sketch shown in Fig. 363 will answer for a center bent in either of the previous examples, as it forms a good truss in assisting the swing beam in carrying the upper structure.

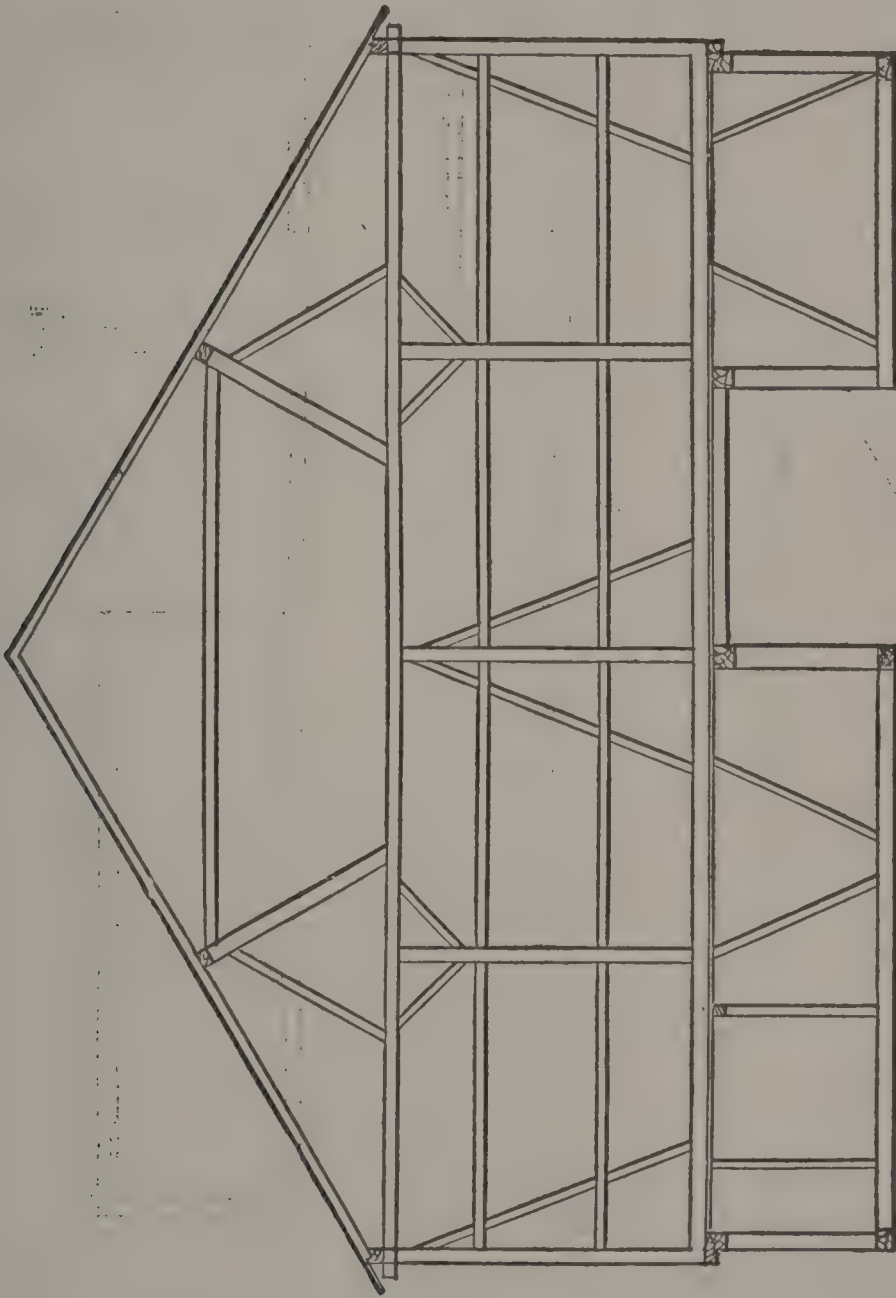


Fig. 362.

Fig. 364 shows the side of a barn 65 feet long. This framing will suit any length of barn, and

may be covered by any kind of a framed roof of the usual style. The openings may be filled in with studs and braces, or may be covered in with heavy rolling doors.

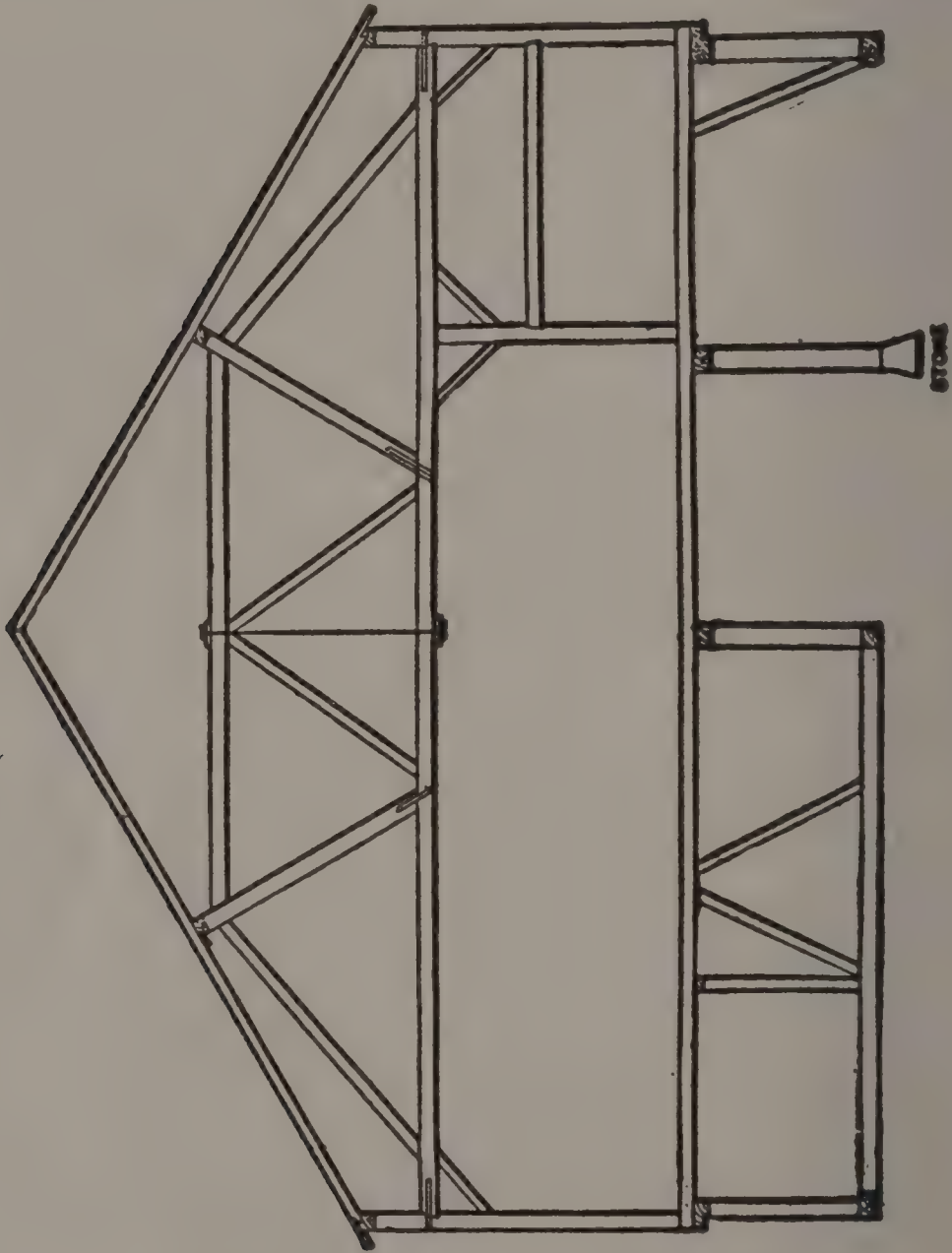


Fig. 363.

The sketches shown at Figs. 365 and 366 are intended to apply to roofs having a span of not more than 40 feet. The roof shown at Fig. 365 is

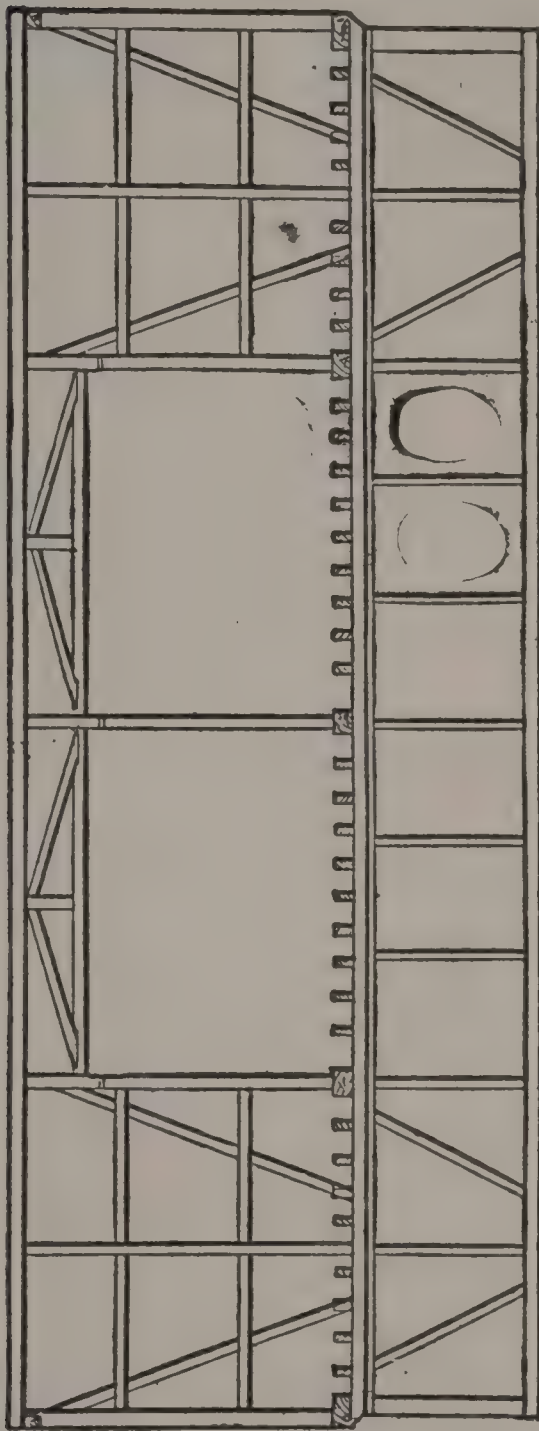


Fig. 364.

nicely adapted for using a "hay fork," as the timber in the ridge will accommodate the fork and its appliances.

I show a number of designs for framing barns with gambrel roofs at Figs. 367, 368, 369, 370, 371

and 372. These will, I think, be ample to meet almost any requirement in this class of roofs. Figs. 369 and 370 appear to be favorites with framers in some parts of the west where there are barns that have been built on these lines over thirty years ago, and which are still doing good service after "braving the battle and the breezes and cyclones" so long, and they still give promise of doing business at the old stands for many years yet to come.

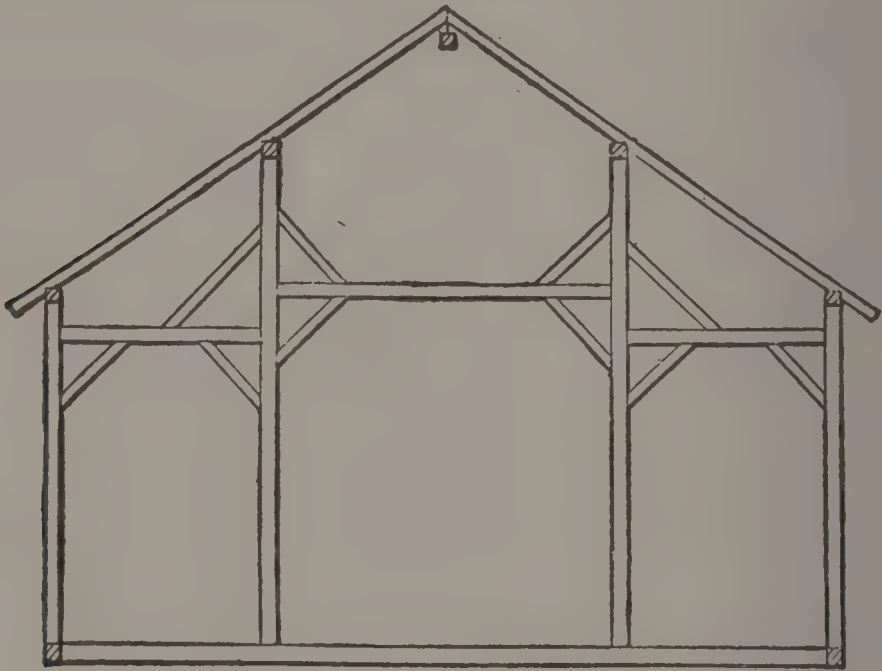


Fig. 365.

Temporary seats, or "grand stands," for fairs, exhibitions, outside conventions or similar occasions, are often called for, and the man who knows how best and most economically to build same will be the man to secure the contract for such work.

While I do not intend to go deeply into this phase of timber framing, I deem it due to my



Fig. 366.

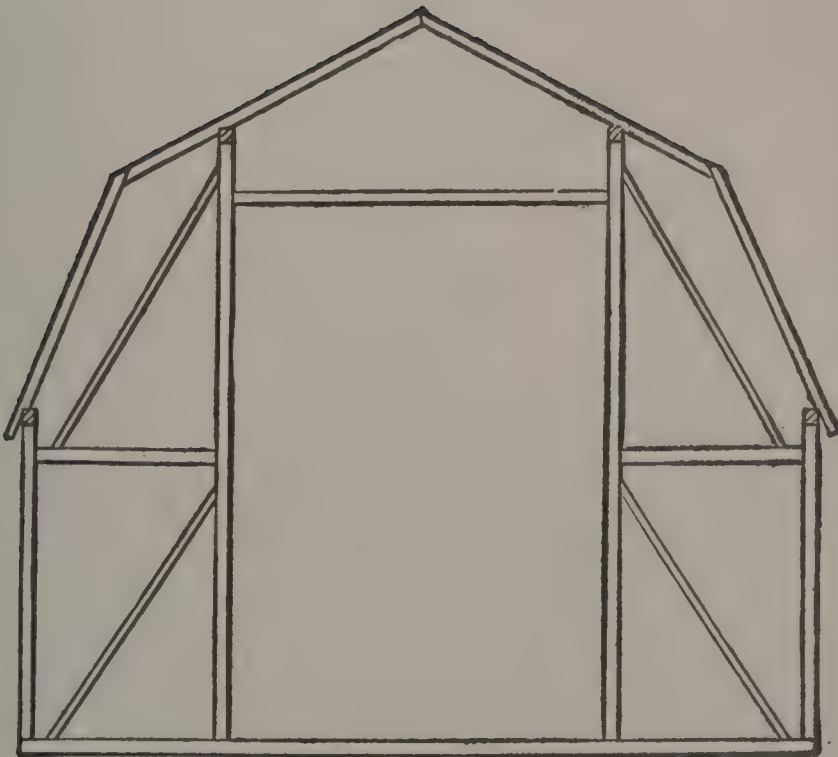


Fig. 367.

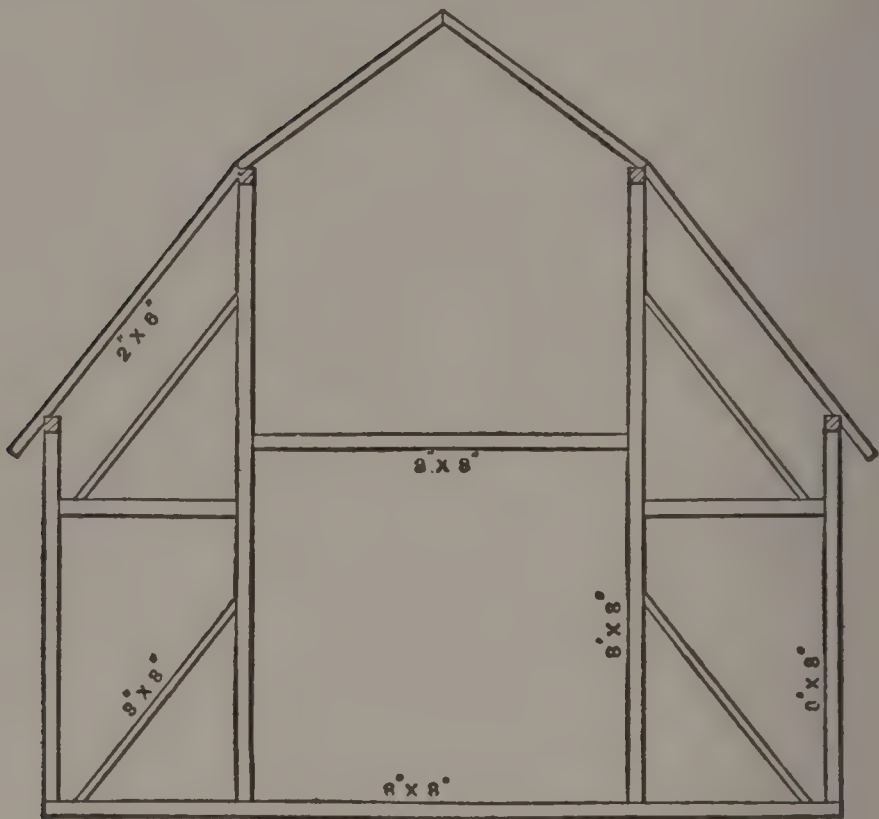


Fig. 368.

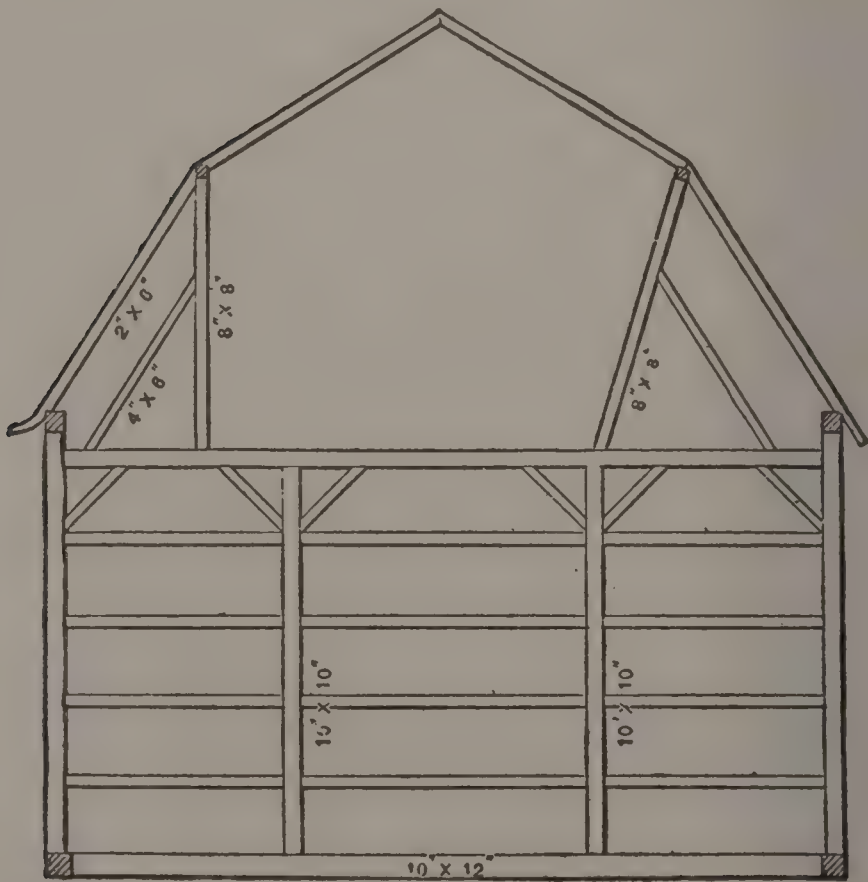


Fig. 369.

readers that I should submit something to them that may be of use should they ever be called upon to erect structures of this kind.

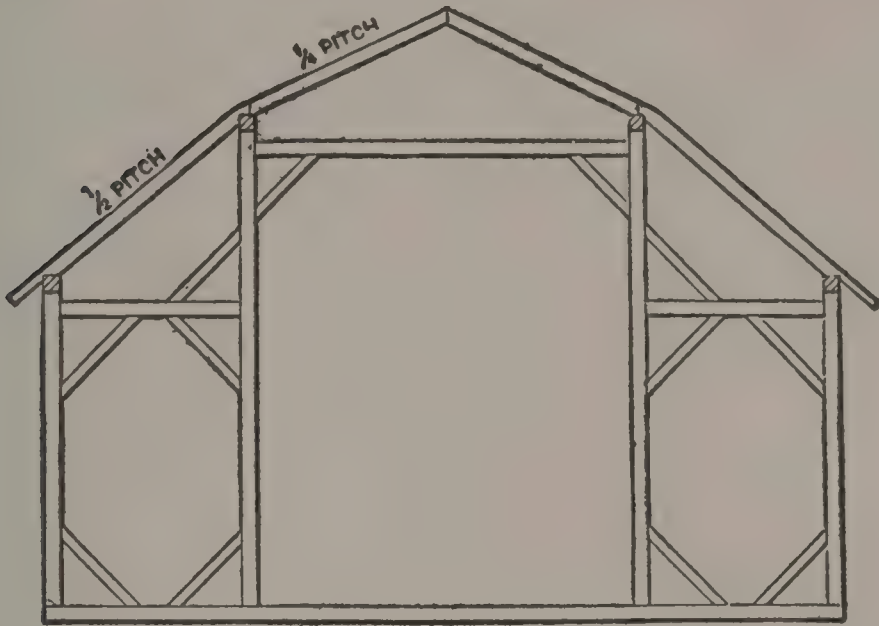


Fig. 370.

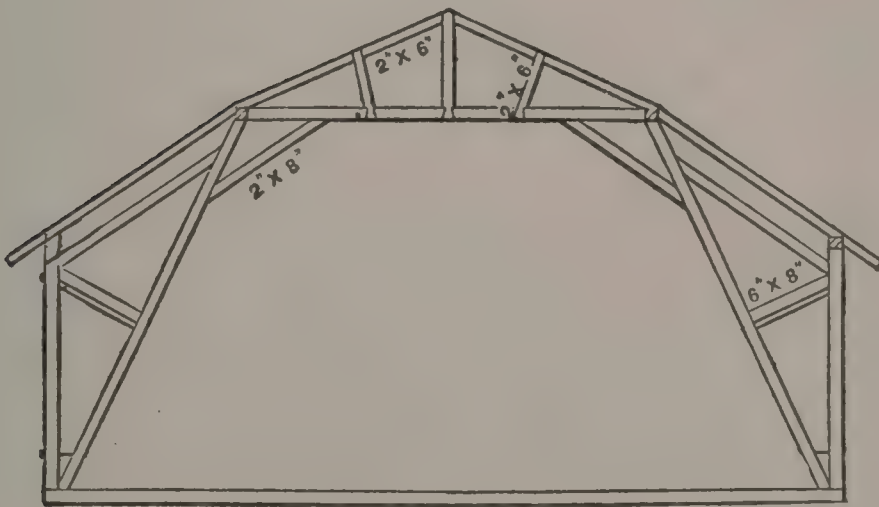


Fig. 371.

To build a temporary lot of seats where the space is limited between walls, the proposition is rather a simple one, as the framing may easily be

erected and slightly attached to the walls, or, if the walls permit of it, timbers may be laid so that their ends may rest in the walls, and they may be

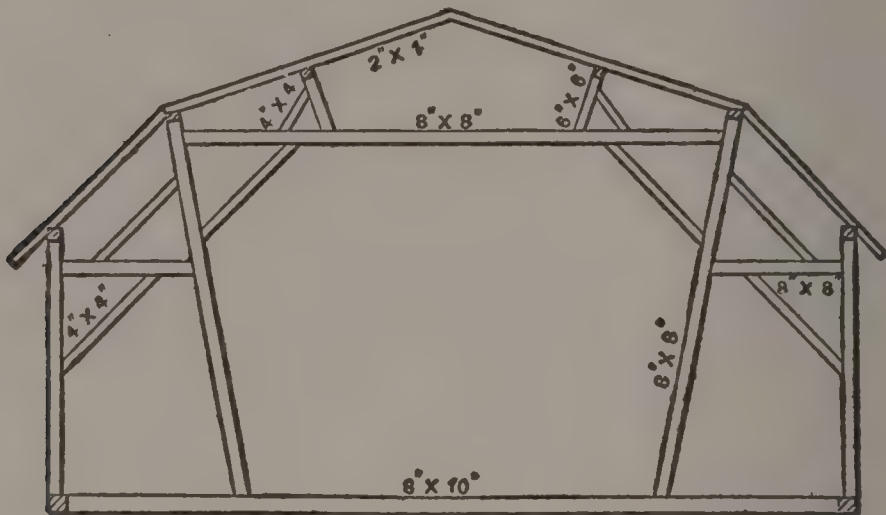


Fig. 372.

supported through the center by a triangular framework, such as shown at Fig. 373, and the seating may be built on as shown in Fig. 374.

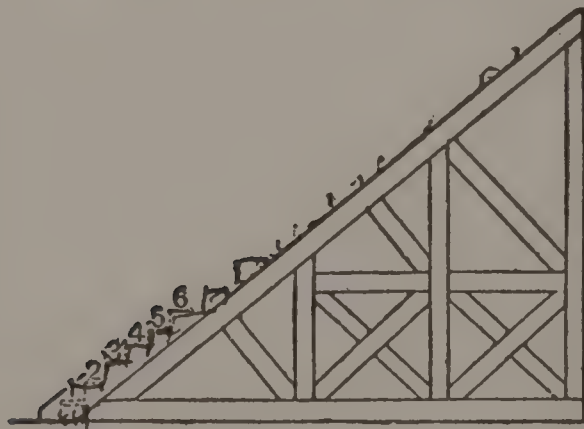


Fig. 373.

This shows the principles on which all stands of this kind are built. Sometimes the timber and planking are all spiked or nailed together. This

is objectionable as in that case all the bearing strength of the frame must be on the nails or spikes, something that should not be. A much

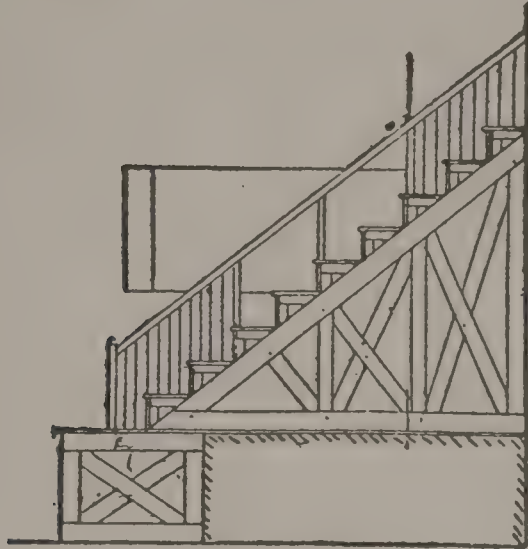


Fig. 374.

better way would be to put the frame together with large screws or bolts, then the framework can be taken down without much injury to the

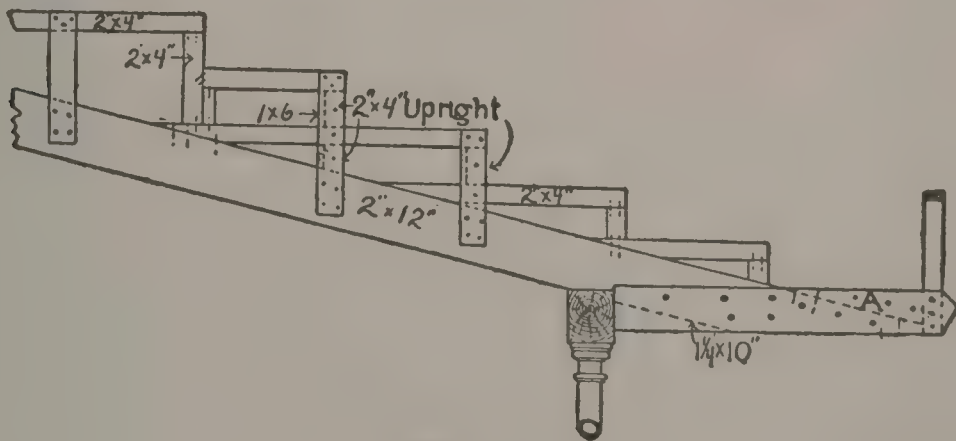


Fig. 375.

material. If the seats are to have benches on them, and to be raised above the ground at the lower end the steps must be made wider to suit

these conditions, as shown at Fig. 375. If chairs are to be used on the platform the steps should not be less than 2 feet 4 inches wide, each having the proper rise. The diagram shows how such steps can be formed with a minimum of both materials and labor.

Another manner of constructing these galleries is shown in Fig. 376. In this case the upper platform is left about 5 feet 4 inches wide, which

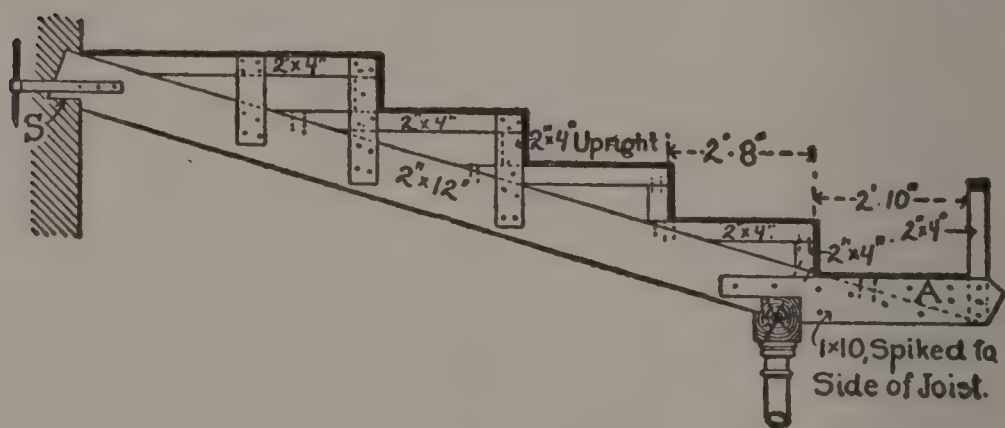
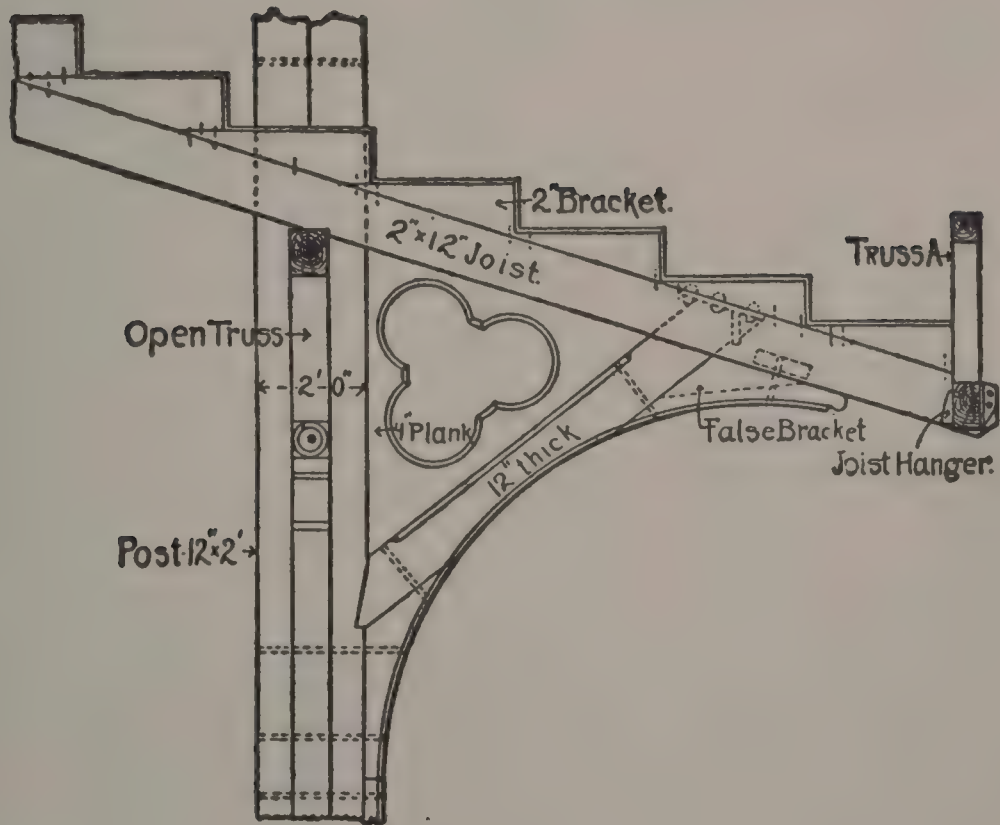
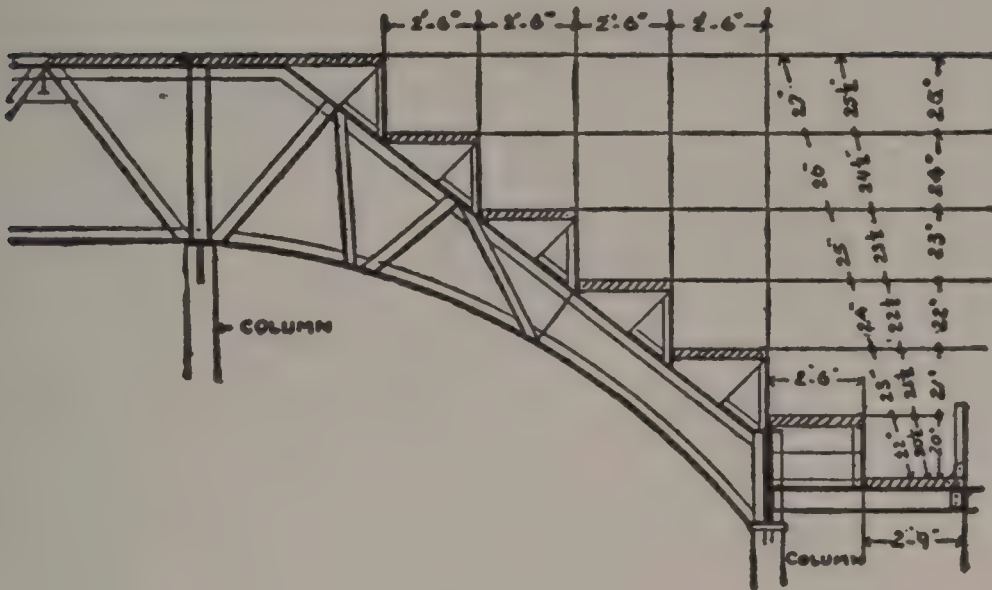


Fig. 376.

leaves room enough for seating on the step and for people to pass to and fro between the wall and the rear of the people on the seat. The diagram shown at Fig. 377 has a much steeper pitch, and is built over a series of trusses. This admits of the lower portion of the truss being arched, which gives more headroom to the floor below. The treads or steps in this series are much narrower than those shown in previous examples.

Fig. 378 shows a portion of a gallery having an



arched ceiling and an ornamented panel in the angle which relieves the work and makes a good finish. Another scheme is shown in Fig. 379.

This is figured on the plan so there is no need of further explanation.

Two other examples are shown at Fig. 380. The principal B is notched on the wall-plate G, and also on the beam E; the tie is secured on the wall-plate H and bolted to the principal. F is a beam

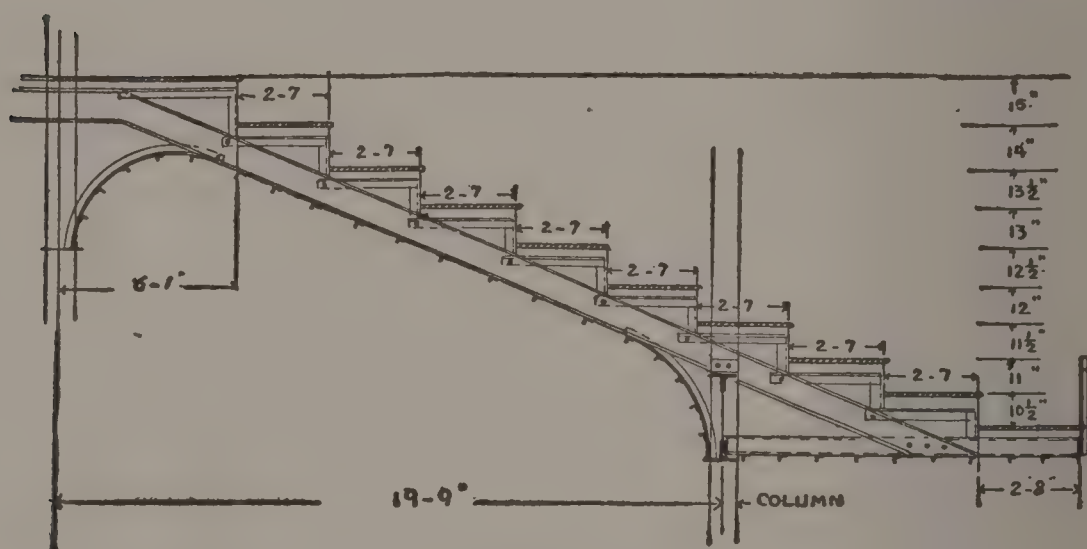


Fig. 379.

serving the office of a purlin to carry the gallery joists; D is a strut; bb are the floors of the pews or seats; and ccc the partitions; C is a hammer-piece or bracket resting on the beam E and bolted to the principal B; its outer extremity carries the piece I, which supports the gallery front.

No. 2, Fig. 380, is another example of the trussed principal A D C E, resting on the wall-

plate H, and front beam E supports the beam K, which carries the gallery joists B; a a and b b are the floors and partitions of the seats.

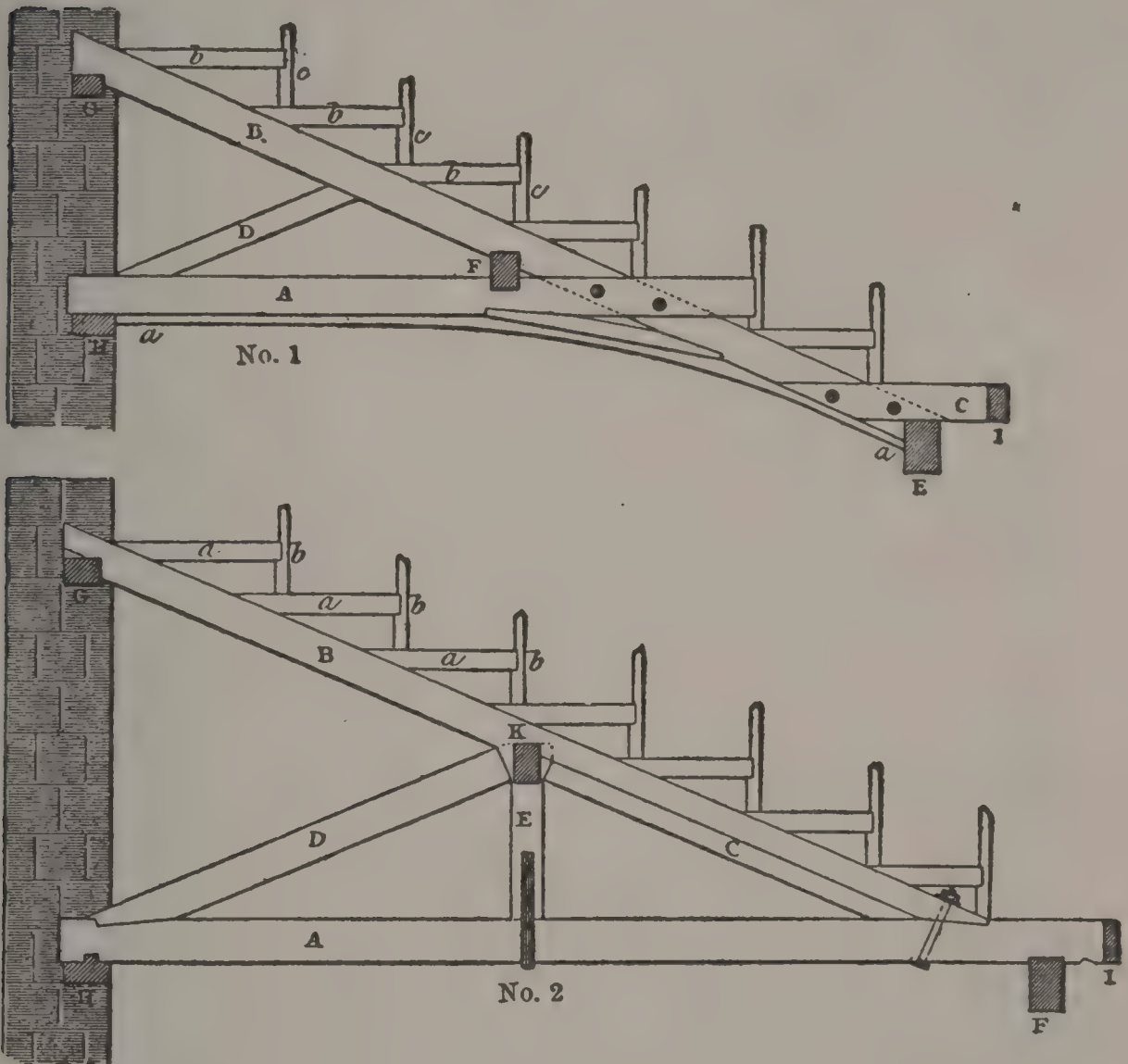


Fig. 380.

In building stands of this kind, or designing same, nothing should be let go as “good enough” if there be anything at hand better. All timbers should be of the very best and the workmanship beyond suspicion. In no other structure is hon-

est work and faithful adherence to good and strong construction more needful than in the building of temporary structures of this kind.

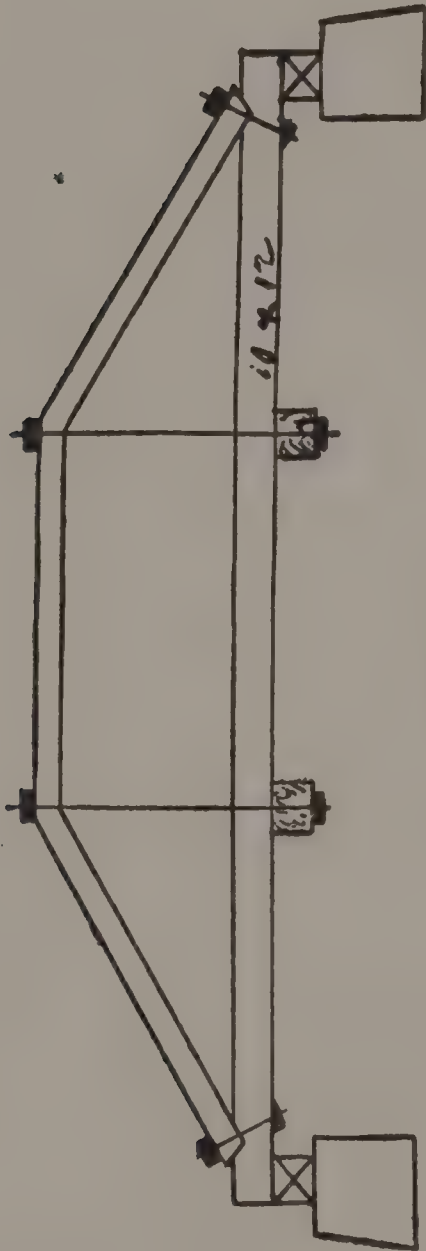


Fig. 381.

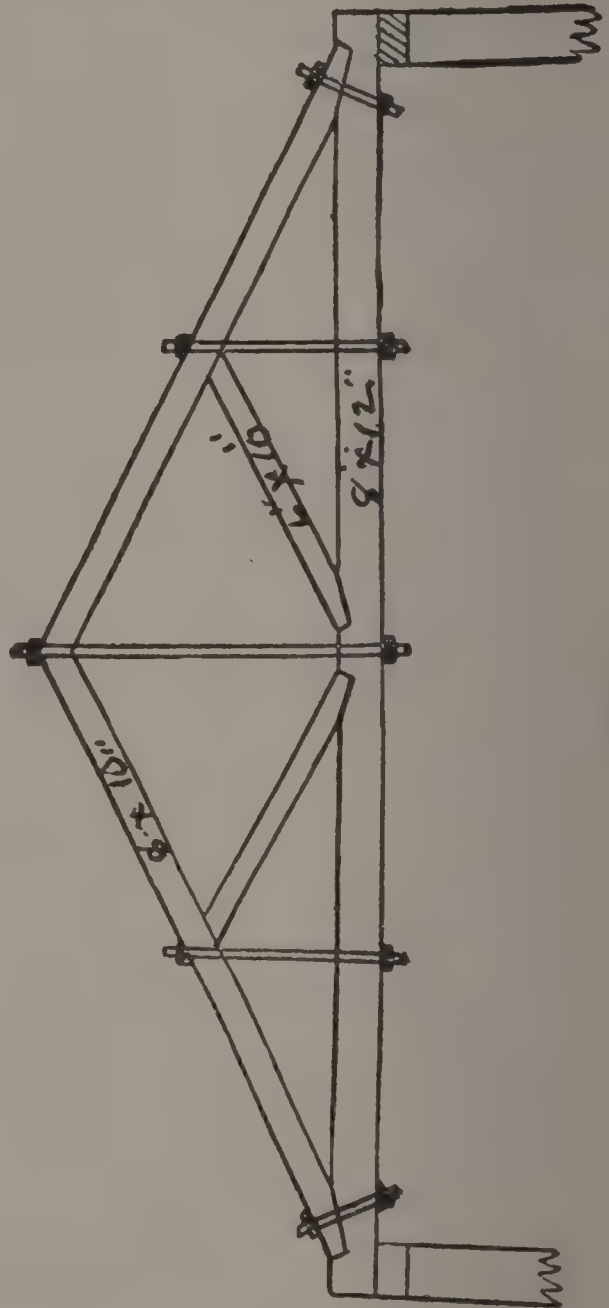


Fig. 382.

What a terrible thing it would be if, because of your carelessness, incompetency, or defect in materials used in the stand or gallery, the whole

structure loaded with young children and lady teachers, was to give way and throw every one to the ground or next floor, causing, perhaps, the loss of many young lives and many bone fractures. See that the timber is sound, that every joint fits snug and tight. Be sure of your foundation; have the building well braced, and your sleep will not be disturbed by fear of the tumbling down of your framed work.

The framing of bridges for short and medium spans, particularly in country, villages and towns, will generally fall to the lot of the expert framer. The designing of these bridges will also be executed by the carpenter and framer; and knowing this, I would not be doing my duty to the country carpenter if I did not submit a number of diagrams herewith for his guidance.

The design for a simple cheaply made bridge, shown at Fig. 381, is quite suitable for a road bridge having a span of about 30 ft. The timbers shown under the main chord tend to strengthen the whole work. The long timbers running across the creek will require to be as long as the chords of the truss; they will rest on the string pieces, and should be bolted down to them. They should be placed not more than 6 feet from center to center. The deck of the bridge should be made of good sound 3 inch plank. The iron rods used in truss should be not less than seven-eighths of an inch in diameter.

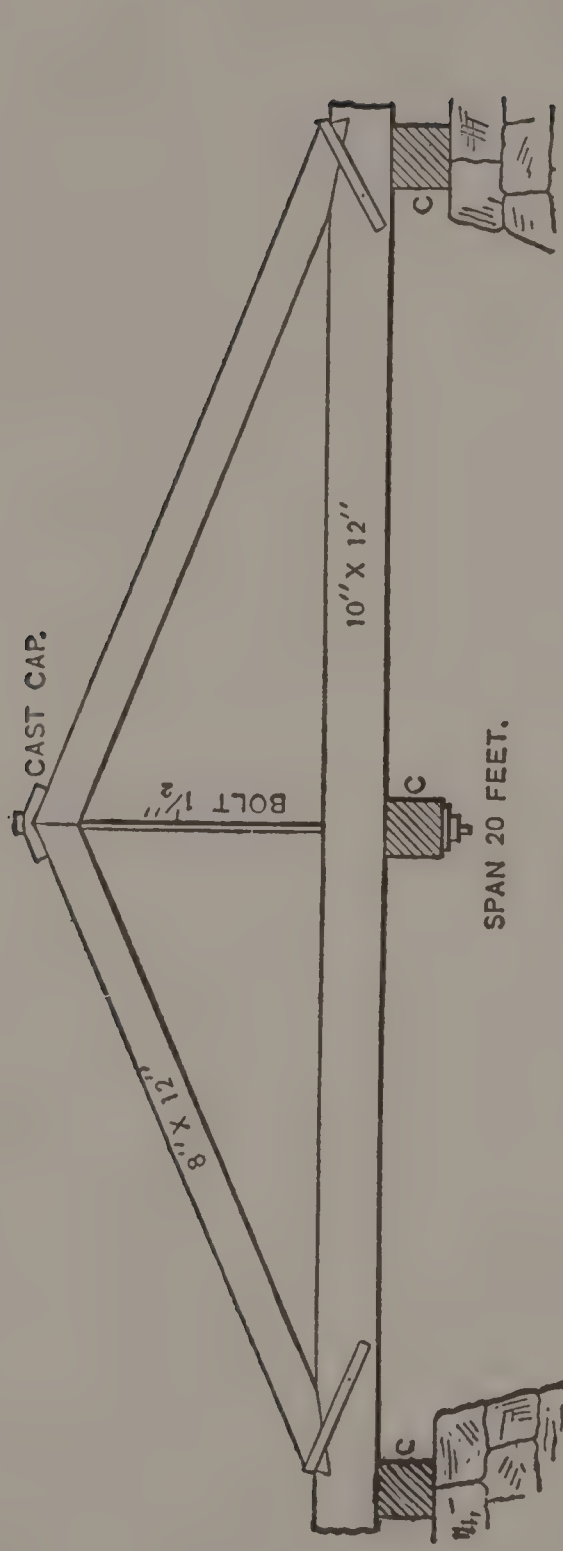


Fig. 383.

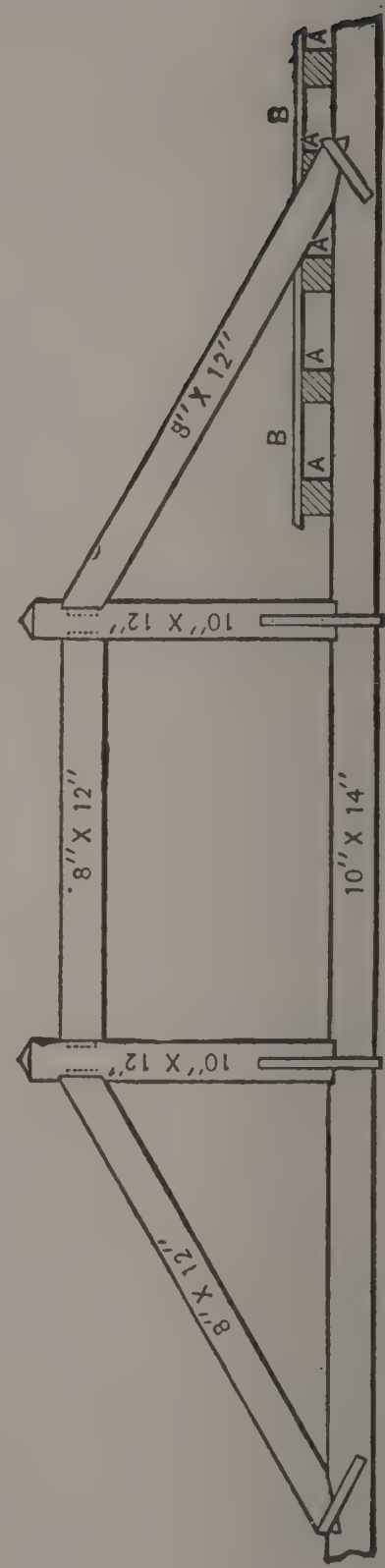


Fig. 384.

Another truss bridge is shown at Fig. 382, which is a trifle easier to build than the one just shown. This is for from 18 to 22 feet span. Sizes of timber are figured out on the diagram.

The design shown at Fig. 383 is a most excellent one for a span of about 20 feet. This bridge will carry an enormous load if skillfully built. The timbers are all marked with figures, giving sizes of stuff required. This bridge, with plenty of stringers in it, would carry a railroad train. For foot bridges, either of the designs shown would answer very well, with about half the timbers in them as described on the diagram.

A very strong truss is shown at Fig. 384, that is suitable for a span of 50 feet, or even a little more. A part of the deck floor is shown at B B, and the cross timbers appear at A, A, A. This makes a good substantial bridge for a roadway and is very popular in many country places.

The design shown at Fig. 385 is made for a span of 40 feet. This is also a good design for a general roadway.

Another good truss is shown in Fig. 386 and one which is intended for a span of 75 feet. The bridge is 12 feet wide between trusses. The stringers rest on the cross-ties or beams A. The floor consists of 2-inch plank nailed on the stringers. The braces butt against a block which is bolted to the chord with two bolts $\frac{3}{4}$ -inch in diameter. The heel of the brace is also fastened to the chord with two

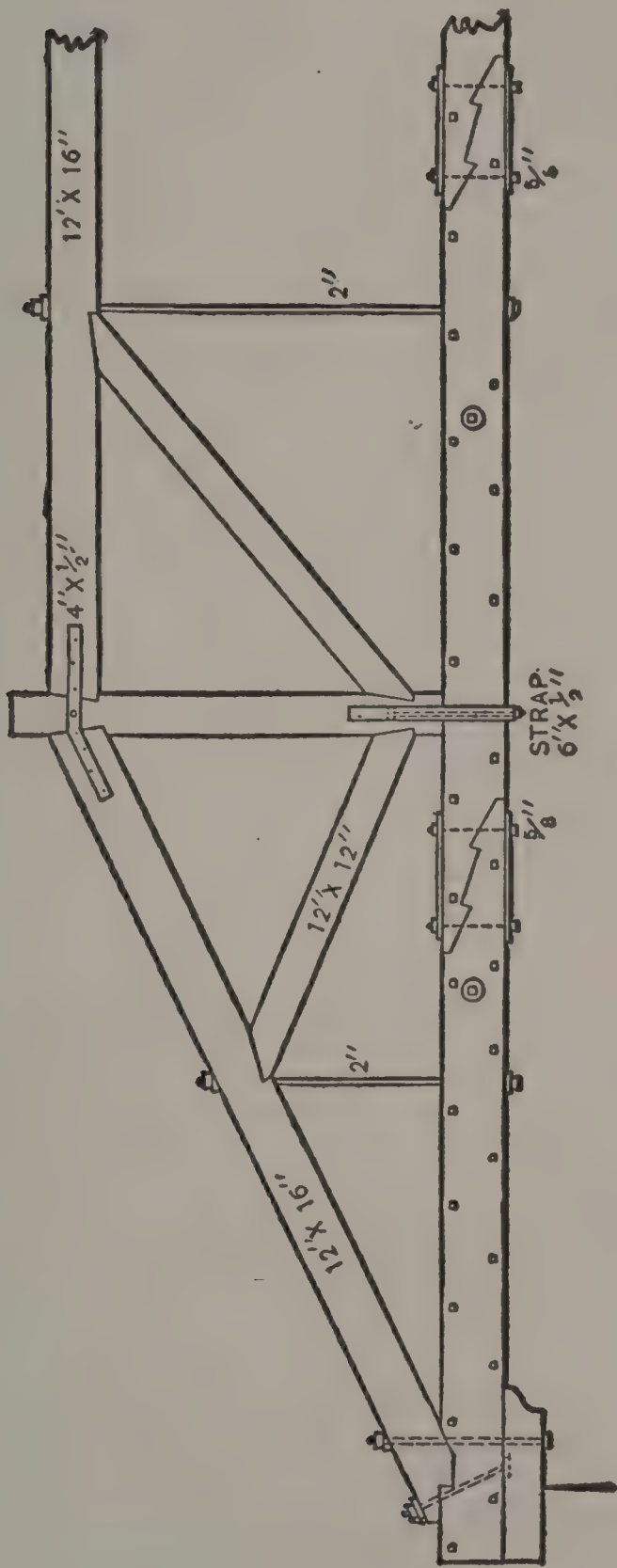


Fig. 386½.

bolts of the same size. At the point B there are two pieces 6x12 inches, notched and bolted with

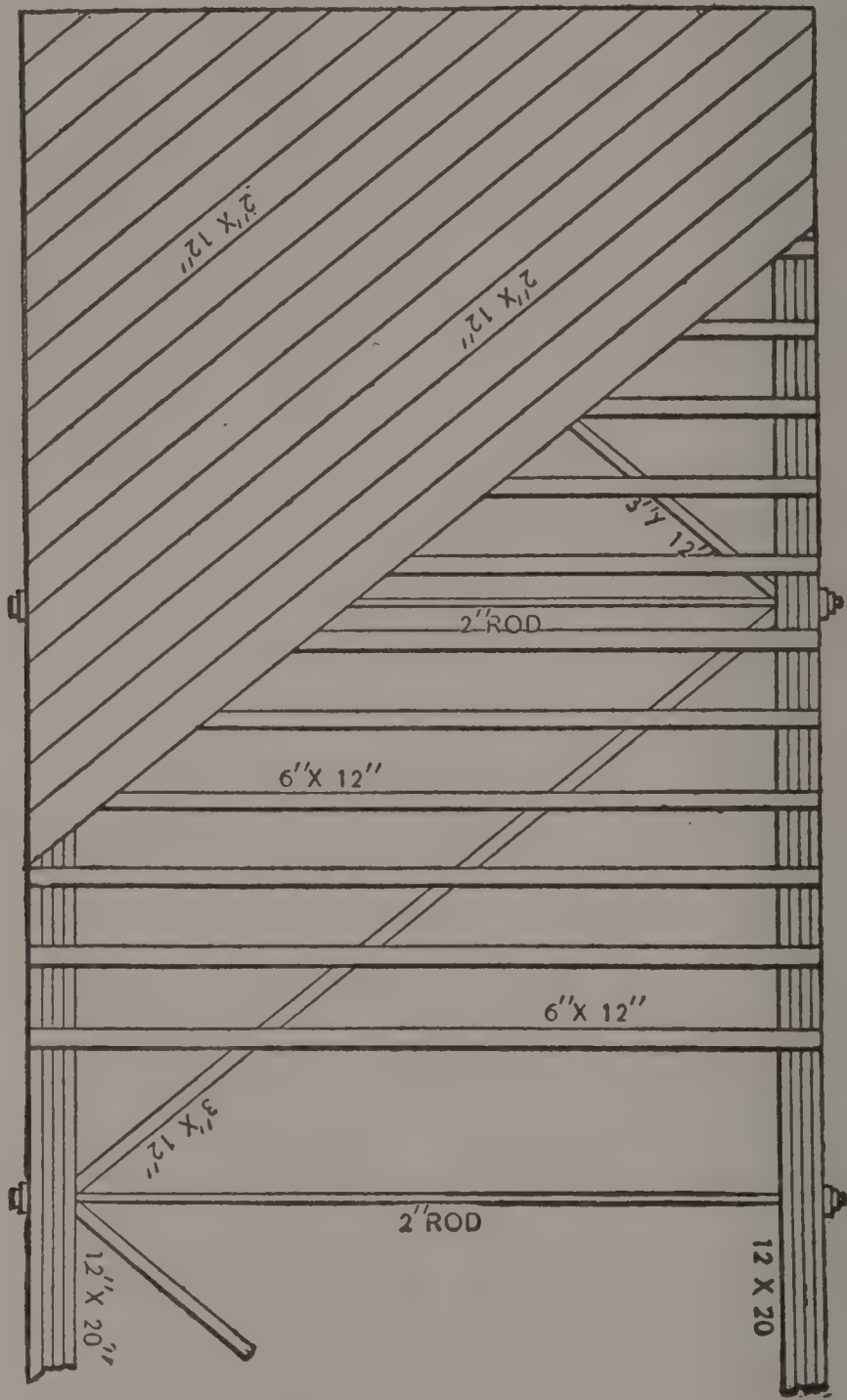


Fig. 387.

two bolts at the top and bottom. There is only a common key splice in the center of the chord. I do not think this to be a very strong bridge for

this span, but I would suggest that in making use of it, it should be limited to a span of not more than 65 feet.

The trussed bridge shown at Fig. 386 $\frac{1}{2}$, is heavy enough for a railway bridge, though it is not intended for that purpose, having been designed for a roadway where much heavy traffic passes over it. The illustrations, Figs. 387 and 388, clearly show the construction and sizes of the different parts. Where strength and stability are desired I would not recommend that the parts be made lighter than indicated. In addition to the elevation of the truss, a plan is shown of the roadway, including the cross-braces, floor beams and planking. The cross-braces are 3x12, the floor beams 6x12, and the planking 2x12, laid diagonally. Other necessary particulars are furnished by the drawings, as Fig. 338 shows a portion of the deck or platform.

This truss shown at Fig. 388 is for a span of about 72 feet. The illustration showing the construction requires no explanation other than to say that the rods and plates should be provided with cast-iron washers of such shape that all the nuts will fit square with the bolts. The washers at the angles of the main braces and upper curves are made to take both rods and to extend over the joint sufficiently to hold the brace. The bridge shown is 72 feet span, or 75 feet extreme length. It has a roadway 14 feet wide. This, on a much-

traveled highway would be better 16 feet wide. The bridge should be constructed with about 6-inch spring. If oak timber is used in the construction of the bridge, the dimensions of the pieces may be somewhat reduced from what is shown on the drawing.

The bridge shown at Fig. 389, is a double strut bridge, and is a very strong one; would answer for a roadway where heavy traffic crosses. The two struts, CC, on each side of the center show how it is braced, as also do the struts DD, which add much to the stiffness of the work. A shows the stringer, while B shows the timber for abutting the long struts against.

Another bridge of nearly the same span is shown at Fig. 390. This is a simple example with one strut on each side of the center of each beam; A is the chord or beam, B the strut, and C the straining-piece bolted to the beam. The rail above the beam is for protection only, and is not intended to bear any part of the load, although, if properly framed, it will be of service in this respect.

When the spans are too great to be bridged in this simple manner, some method of trussing must be adopted. With scarcely an exception, the examples of trussed bridges may be resolved into the following groups (391):

1. Trusses below the roadway, and exerting a lateral thrust on the abutments.

2. Trusses above the roadway, and exerting only vertical pressure on the supports.

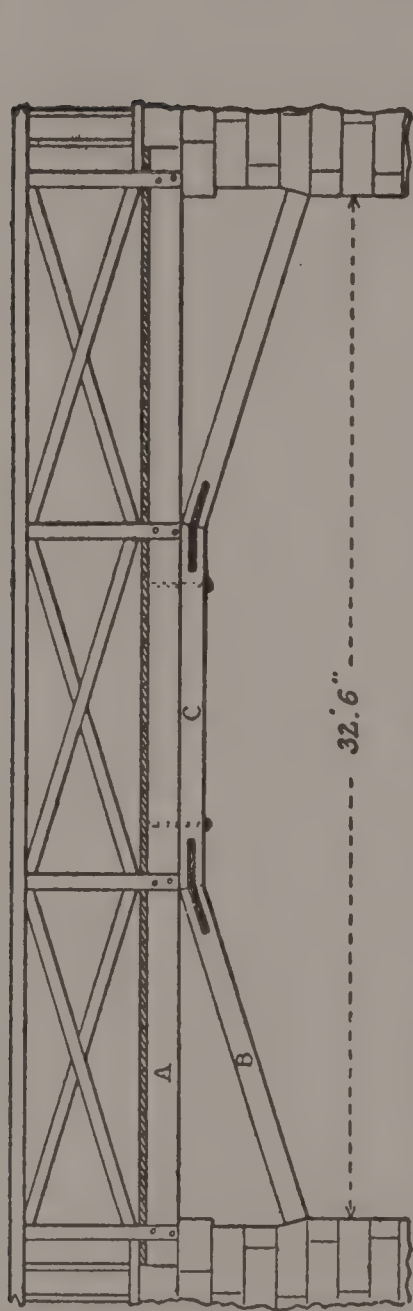


Fig. 390.

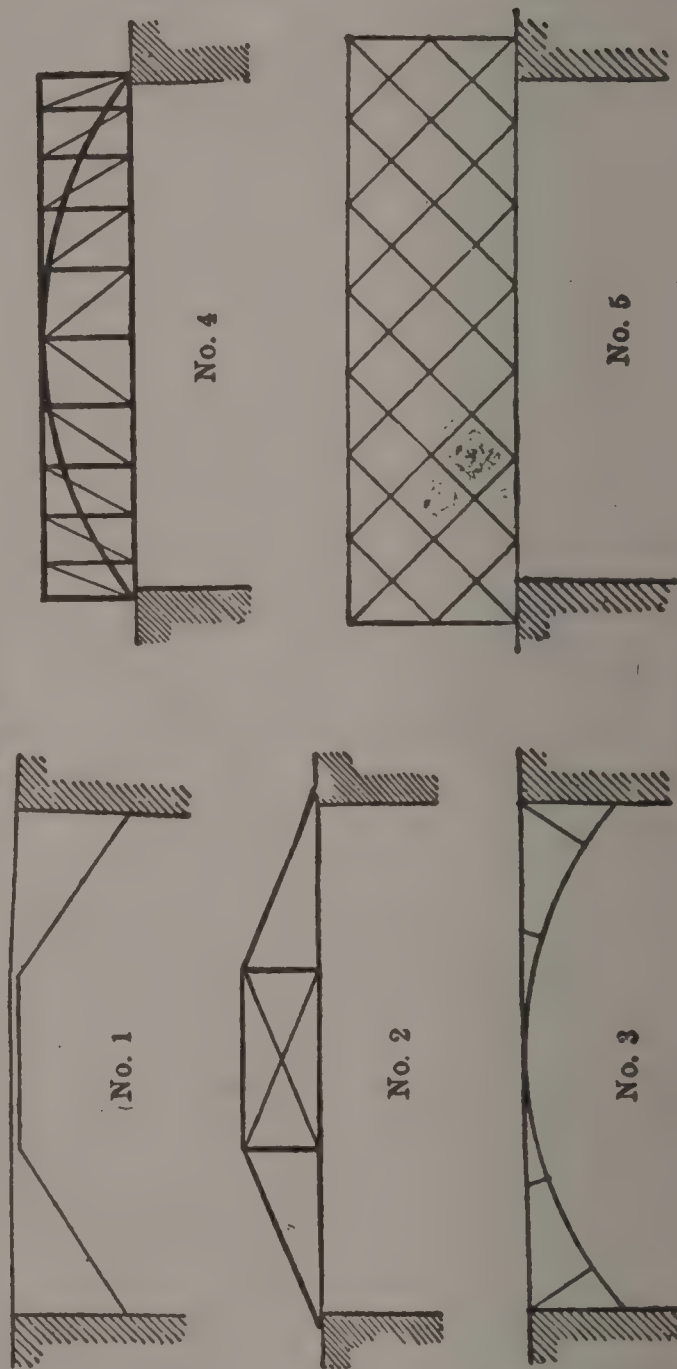


Fig. 391.

3. Trusses below the roadway, composed of timber arches with ties and braces, but dependent on the abutments for resistance to lateral thrust.

4. Trusses below or above the roadway, composed of timber arches with ties and braces, and exerting only vertical pressure on the supports.

5. Lattice trusses above the roadway.

I show a bridge at Fig. 392, having a span of over 100 feet, that is not, properly speaking, a truss bridge, and which is not very difficult of construction. This bridge was built more than fifty years ago by the celebrated Thomas Telford, C. E., and it is still doing good service; and may continue to do so for many years yet, if it gets good care.

I show at Fig. 393 a 100-foot span trussed bridge constructed on the lines of the Howe Truss. I also give some data for figuring on the strength of this bridge and the loads it will carry. The bridge is, of course, a compound structure of steel rods and timber beams, which will probably be best. The dead load may be taken for trial at 7 cwt. per foot run, and the live load will be, say 7 cwt. per foot run, making a total load of $\frac{100 (7+7)}{20}$ 70 tons, or

35 tons on each truss. Assume the elevation to be as shown in No. 1, then the frame diagram will be as shown in No. 2, and the stress diagram as shown in No. 3. It will be necessary also to ascertain the stresses when the first three bays only are loaded, as this puts the fourth bay under a diagonal compressive stress when there is no compression mem-

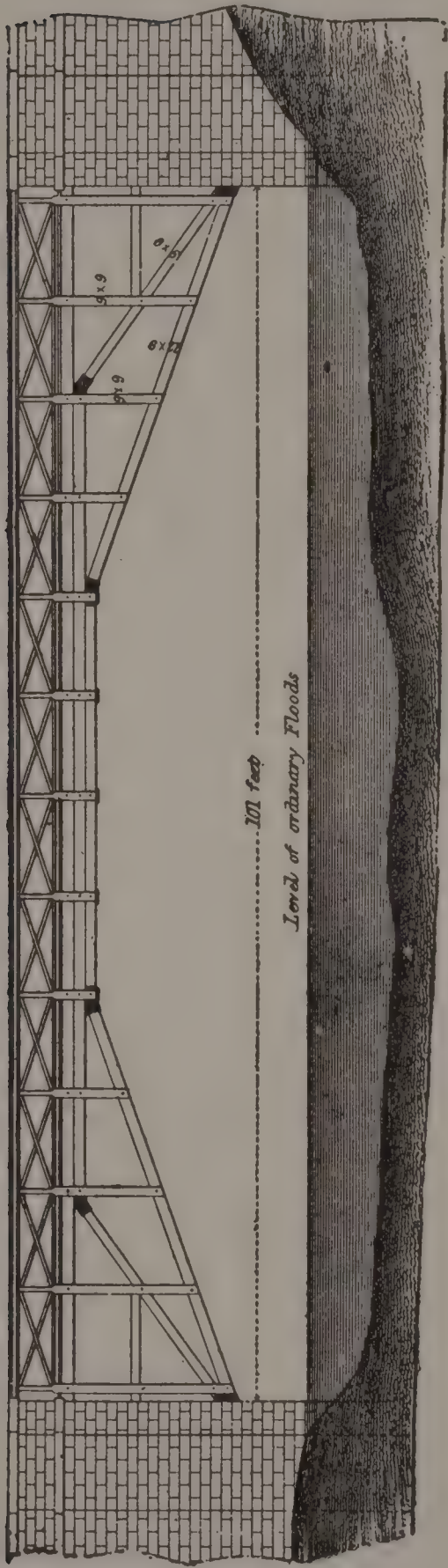


Fig. 392.

ber in the required direction, which is met by the compression member 19-20 undergoing 2.2 tons tension. The frame diagram for this will be as shown in No. 4, and the stress diagram as shown

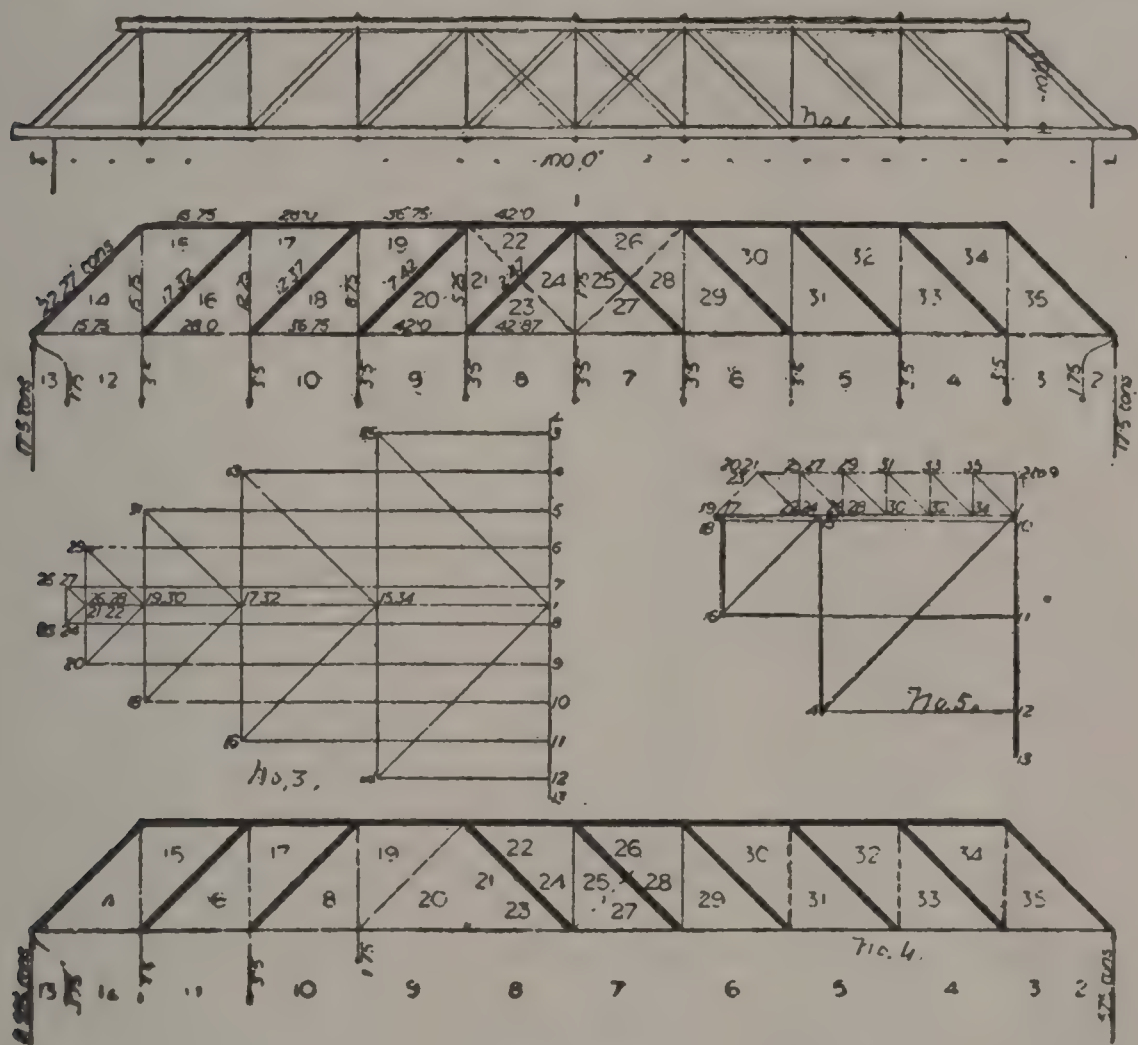


Fig. 393.

in No. 5. The stresses may be measured off the diagrams, and the bridge will then want careful designing to suit the material employed.

In the illustration shown in Fig. 394 is represented an ordinary lattice bridge which may have any ordinary span from 50 to 125 feet. No. 8 is

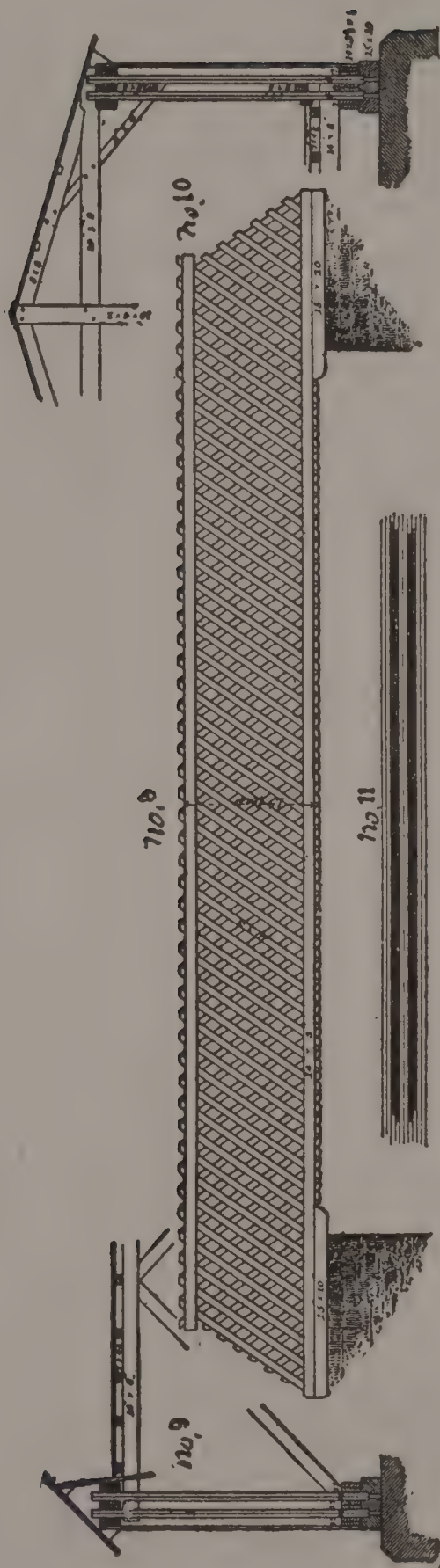


Fig. 394.

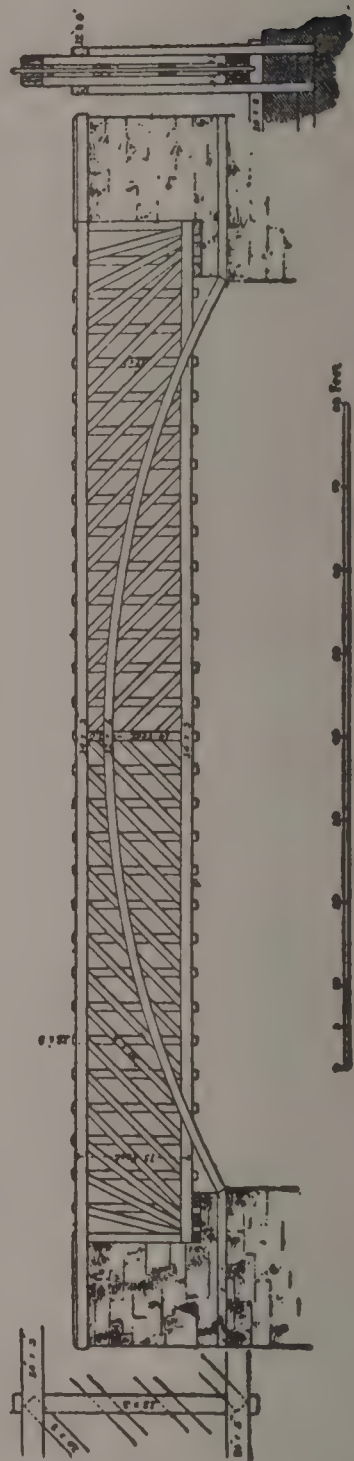


Fig. 395.

the elevation of the common lattice bridge; No. 9, a section of the same when the roadway is above the latticed sides; and No. 10, a section when the roadway is supported on the under side of the lattice. No. 11, plan of one of the latticed sides.

Although when first introduced the lattice construction at once obtained great favor from its simplicity, economy, and elegant lightness of appearance, yet experience has shown that it is only adapted for small spans and light loads, unless fortified by arches or arch braces. When well constructed, however, it is useful for ordinary road bridges where the transport is not heavy.

A lattice-truss is composed of thin plank, and its construction is in every respect such as to render this illustration appropriate. Torsion is the direct effect of the action of any weight, however small, upon the single lattice.

Fig. 395 exhibits an elevation and details for an improved "Steele" lattice and trussed bridge, which is intended for long spans. The example shown was built over a span of more than 200 feet. The arch shown in the work adds to the stability of the work very materially.

The details shown are self-evident and hardly require explanation.

In building a Howe truss, it is quite essential that the chords be arched or cambered. There are several ways of getting this camber, but the one recommended by Prof. De Volson Wood of Ste-

vens' Institute, Hoboken, N. J., is perhaps, about the best. He says: "Camber may be accomplished in various ways. Having determined the length of the main braces for straight chords, if their length be slightly increased, beginning with nothing in the center and increasing gradually towards the ends, any desired camber may be secured. This will give an arch form." The result, in an exaggerated form, is shown in Fig. 396. The bolts shown are all supposed to radiate to the center of the arch.

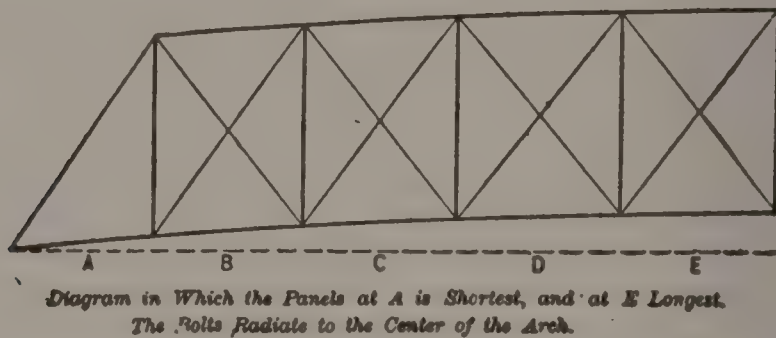


Fig. 396.

The object of cambering a truss is to allow for any settlement which may occur after completion, and also to prevent the truss from deflecting below a horizontal line when taxed to its maximum capacity. Some engineers allow 1-inch camber for a span of 50 feet; 2 inches for 100 feet, etc., while some, depending on the accuracy of their work, allow only one-half this amount. By cambering the horizontal timbers it is manifest that they must be made longer than the straight line which joins

their ends. The increase in length of the lower chords due to cambering would be so trifling that in ordinary practice it could be entirely disregarded. Not so, however, with the upper chord; the increase in length of this member would be quite an appreciable quantity, because the top chord is cambered to a curve which is concentric to the curve of the lower one.

Trautwine and other authorities give a rule for determining this increase when the depth, the camber, and the span are given, providing, however, that the camber does not exceed one-fiftieth of the span,

$$\text{Increase} = \frac{\text{depth} \times \text{camber} \times 8}{\text{span}}$$

using either feet or inches in the calculations. By cambering the truss the distance between the suspension rods on the upper chords will necessarily be greater than the distance between the rods on the lower chords. The panels are not strictly parallelograms, the rods converging somewhat. By dividing the total increase in length of the upper chord by the number of panels in the truss we obtain the increase per panel. This, of course, will effect the length of the braces, and great care should be taken to cut these to the proper length. Trautwine also gives a method for finding the length of the braces in cambered trusses, but while the method shown is practically correct, in so far

as lines are concerned, yet it could not be applied very well in a timber truss, at least, not so well as the method shown previously.

It must be remembered, that in calculating strains in trusses, skeleton diagrams are used, and the lines composing these diagrams are generally taken or drawn through the axes of the various members. These lines usually meet at a common point of intersection as will be seen from the dotted lines in Fig. 397. But in practice these lines

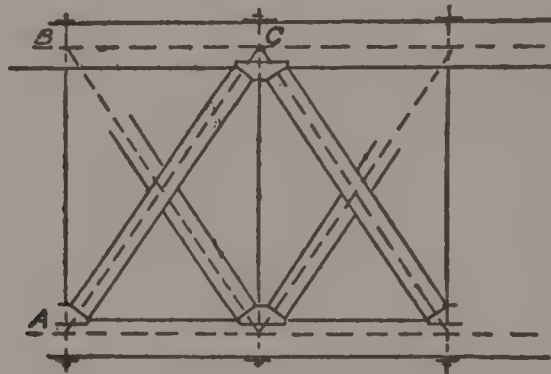


Fig. 397.

do not always thus meet. The method shown by Trautwine is that of finding the length of the hypotenuse AC of the right angled triangle ABC; and even were these axial lines to meet at a common point of intersection the rule would not apply on account of the angle blocks taking up part of the distance. The best way to get the length would be to lay out one panel full size.

I show, at Fig. 398, a diagram of a Howe truss complete. This will give an idea of the way in

which these trusses are constructed. A theoretical description of these styles of truss would scarcely be in place in this treatise, because of the fact that the carpenter who does the framing has but little to do with the theory, and because of the other fact that there are a number of excellent treatises in the market.

Another branch of timber framing is that of "shoring and needling," which may be analyzed as follows:

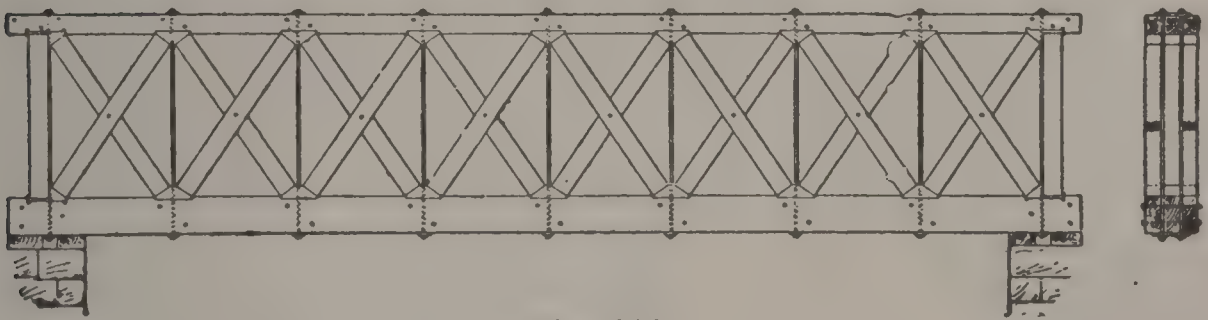


Fig. 398.

A system of raking shores, Fig. 399, consists of from one to four inclined timbers ranged vertically over each other, their lower ends springing from a stout sole-piece bedded in the ground, and their upper ends abutting partly against a vertical plank secured to the face of the wall and partly against the "needles"—horizontal projections that penetrate the wall-plate and the wall for a short distance.

The needles are generally cut out of 3-inch by 4½-inch stuff, the entering end reduced to 3-inch

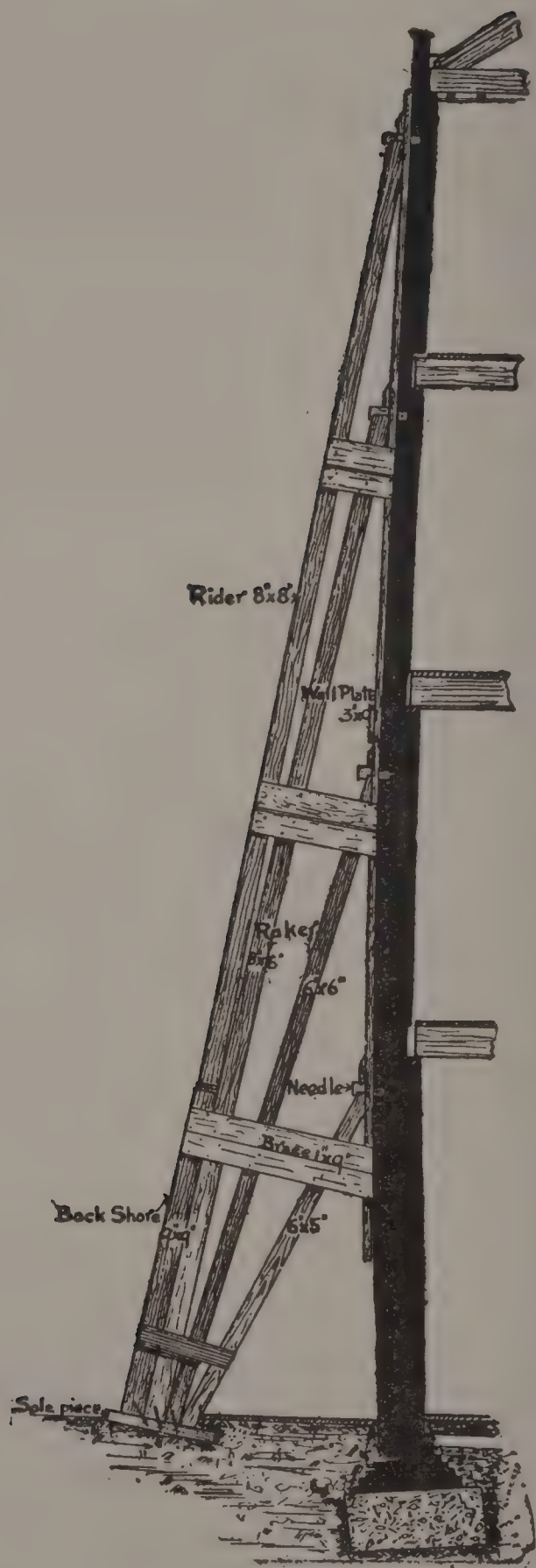


Fig. 399.

by 3-inch for convenience in entering an aperture formed by removing a header from the wall. The shouldered side is placed upwards, and cleats are fixed above them into the wall-plate to strengthen their resistance to the sliding tendency of the

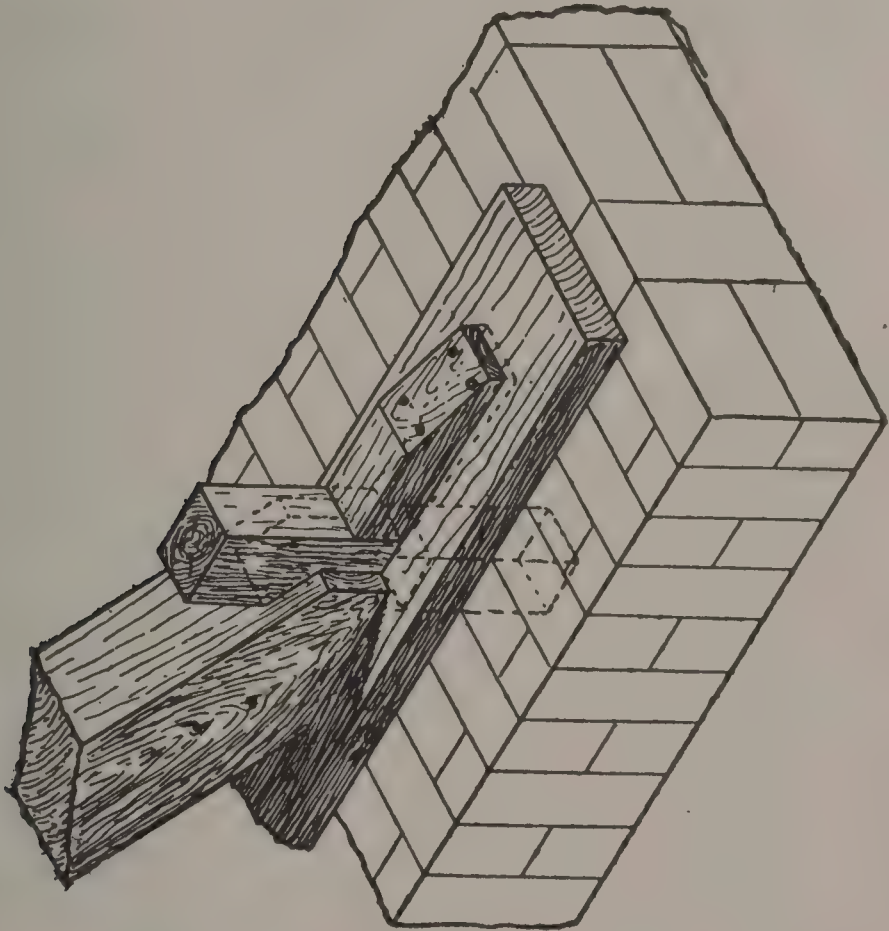


Fig. 400.

shore. They are preferably sunk into the plate at the top end as indicated by the dotted lines in Fig. 400.

The head of the raker should be notched slightly over the needle, as shown in the detail sketch, Fig. 400, to prevent its being knocked aside, or moving

out of position in the event of the wall settling back.

The top shore in a system is frequently made in two lengths for convenience of handling, and the upper one is known as the "rider," the supporting shore being termed the "back shore."

The rider is usually set up to its bearing with a pair of folding wedges introduced between the ends of the two shores. (See Fig. 399.)

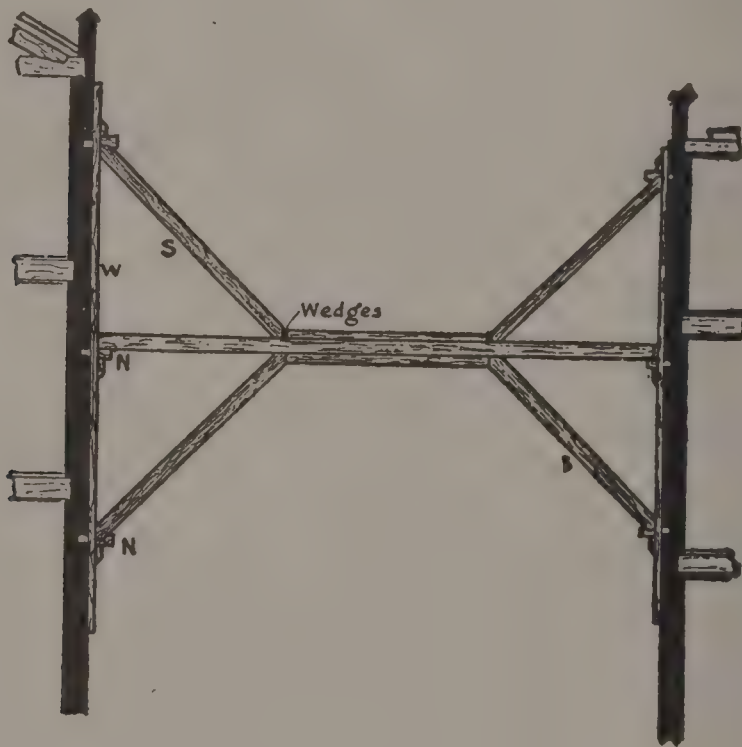


Fig. 401.

Braces are nailed on the sides of the rakers and edges of wall-plate to stiffen the former.

The sole-piece is bedded slightly out of square with the rakers, so that the latter may tighten as they are driven up.

The shores should be secured to the sole-piece with timber dogs; and, when in roadways or other public places, it is wise precaution to fix several turns of hoop-iron around their lower ends, fixing these with wrought nails.

A system of flying shores, see Figs. 401 and 402, consists of one or more horizontal timbers, called

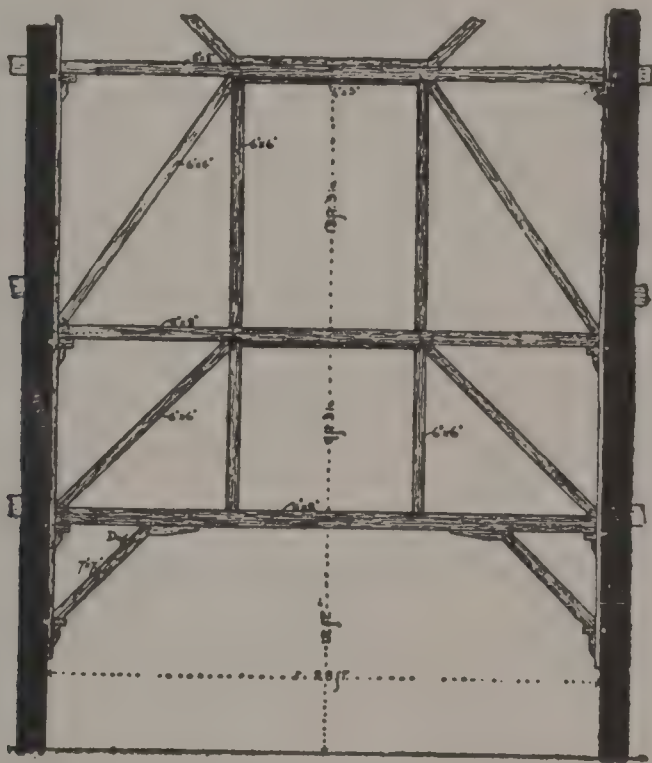


Fig. 402.

“dog shores,” wedged tightly between two wall-plates, secured to the surfaces of adjacent walls. The middle of the shore is supported by braces springing from needles fixed to the lower ends of the plates, and are usually counteracted by corresponding inclined braces raking from the upper ends of the plates.

An angle of 45 degrees is the best for these braces, and abutments for their ends are supplied by straining or "crown" pieces secured to the beam.

Wedges are inserted between the straining pieces and the brace to bring all up tight.

When one shore only is used, the best general position to fix it is about three-quarters the height of the wall, but much depends upon the state of the walls, and the nature or position of abutments behind them.

Where opportunity offers, a complete system of horizontal shores framed and braced to each other, as shown in Fig. 402, is a much safer way to prevent any movement of walls than is a series of isolated shores, which, being erected by different gangs of men, and necessarily under a more divided supervision by the foreman, are likely to display considerable differences in their thrust or resistance to the walls.

Approximate rules and scantlings for raking shores:

Walls 15 ft. to 30 ft. high, 2 shores each system.

Walls 30 ft. to 40 ft. high, 3 shores each system.

Walls 40 ft. and higher, 4 shores each system.

The angle of the shores 60 degrees to 75 degrees—not more than 15 ft. apart.

Walls 15 ft. to 20 ft. high, 4 in. x 4 in. or 5 in. x 5 in.

Walls 20 ft. to 30 ft. high, 9 in. x 4½ in. or 6 in. x 6 in.

Walls 30 ft. to 35 ft. high, 7 in. x 7 in.

Walls 35 ft. to 40 ft. high, 6 in. x 12 in. or 8 in. x 8 in.

Walls 40 ft. to 50 ft. high, 9 in. x 9 in., 50 ft. and upwards, 12 in. x 9 in.

Horizontal shoring: Spans not exceeding 15 ft.—principal strut 6 in. x 4 in. and raking struts 4 in. x 4 in.

Spans from 15 ft. to 33 ft.—principal strut 6 in. x 6 in. to 9 in. x 9 in.; raking struts from 6 in. x 4 in. to 9 in. x 6 in.

The manner of shoring the upper part of a building is shown in Fig. 403. Particulars are given on the illustration, rendering further explanation unnecessary.

Another class of framing I have not yet touched upon is that where a timber structure, such as a tank frame, or a frame for a windmill, is required, and where the four corners lean in towards the center; and I will now endeavor to supply this deficiency: A structure of this kind may be called a "truncated pyramid," that is, a pyramid with its top end cut away at some point in its height leaving a platform level with the horizon, but of course less in area than the base. Thus, if we suppose a timber structure having a base 20x20 feet square, and a deck or platform 12x12 feet square there will be a difference of 8 ft. between

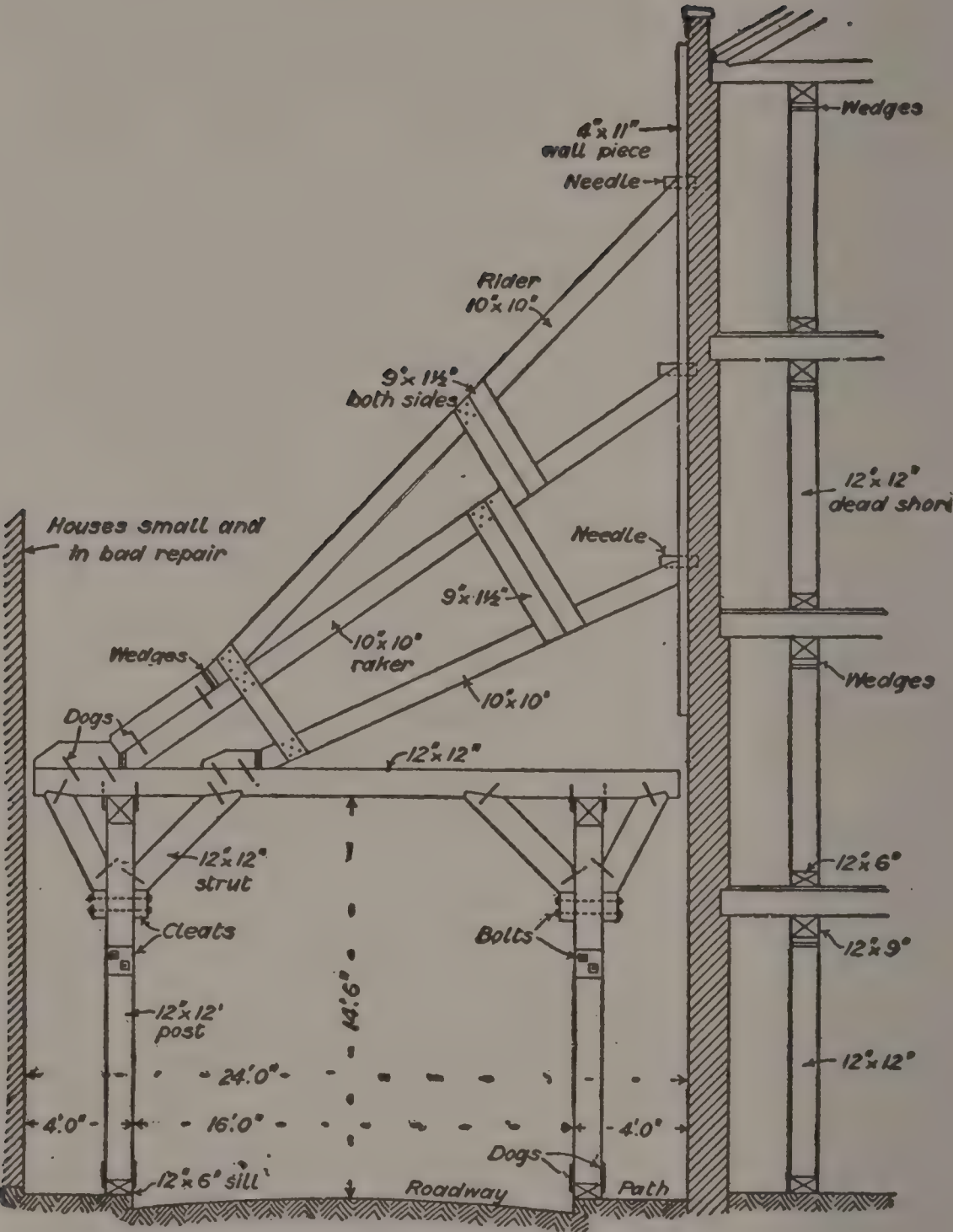


Fig. 403.

the base and platform, or the platform will be 4 feet less on every side than the base, but the center of the base area must be directly under the center point of the platform area. If the structure is 15

feet high, or any other height that may be determined on, the four corner-posts will act as four hips, and will be subject to the same constructional rules as hip rafters, with some modifications and additions to suit changed conditions.

Of the many methods employed of obtaining bevels for oblique cuts on the feet and tops of posts having two inclinations, (and there are many), I

Fig. 404.



Fig. 405.

know of none so simple as the one I am about to describe, and which can be applied in nearly every case where timbers meet at or on an angle, as in the case of struts under purlins, or the junction of purlins under hip or valley roofs. It is extremely handy for finding the bevels required for odd shaped tapered structures.

Let Figs. 404 and 405, show respectively an elevation and a plan of a raking timber meeting at

an angle with a vertical timber. To obtain the bevel shown in the elevation Fig. 404 from the point B, set out a line square with the raking timber and draw the rectangle equal in width to AB, in the plan. Fig. 405, the angle of the diagonal of this rectangle with the pitch of the raking timbers marked F, is the bevel of the bird's mouth

Fig. 406.

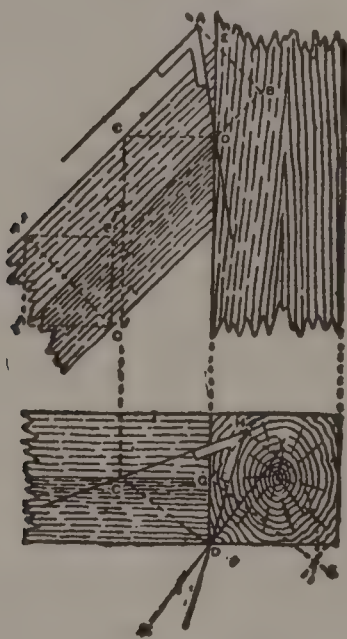


Fig. 407.

with the side. To obtain the bevel from the plan Fig. 405, draw the line CD, and through B, draw CE, equal to BC, in Fig. 404; join CE, and the required angle, which is the same as shown in Fig. 404, is obtained. The bevel required for the side of the strut is the angle made by the pitch of the strut marked C, in Fig. 404, which needs no explanation. Figs. 406 and 407, show respectively an elevation and a plan of a raking timber butting at an

angle against a plank, the section of the raking timber being shown by the dotted lines ABCD, in the same figure; the line AD, being the required bevel, that is, the angle it makes with a line parallel to the edge of the raking part indicated in the figure by the bevel. To obtain the bevel from the plan, draw the dotted line CD, Fig. 406, at right angles to the upright edge of the timber, making the line CG, in the plan Fig. 407, equal to CD, in Fig. 406; draw the dotted line CD, Fig. 407, and at right angles to it draw X, Y, and project the front G, to E, making the distance of E, from XY, equal to the distance DE, in the elevation, Fig. 406; with D as a center, and E as radius, describe the dotted arc until it meets the line XY, and continue it down at right angles to meet a line from G, drawn parallel to XY, in H; then join CHD, and the angle obtained is the bevel required.

Fig. 408, and 409, show respectively an elevation and a plan of timbers both meeting angleways, one of them raking. To obtain the bevel from the elevation, draw the line EF, at right angles to the edge DB, and passing through A, making the distance EF equal to one side of the section AB indicated by the dotted lines in Fig. 408. Draw the line BF and the angle this line makes with a line parallel to the edge is the required bevel for the top surfaces of the raking part which is indicated in Fig. 408, by J.

A similar method is adopted in obtaining the lower bevel, marked K, Fig. 408. The bevels are obtained from the plan Fig. 409, in a similar manner to those in Fig. 407. Make the line HG, Fig. 409, equal to HB in Fig. 408, and continue it down to E at right angles to the side. Join EB and draw XY at right angles; at right angles to XY, project the point A to D, making the height of D, above

Fig. 408.

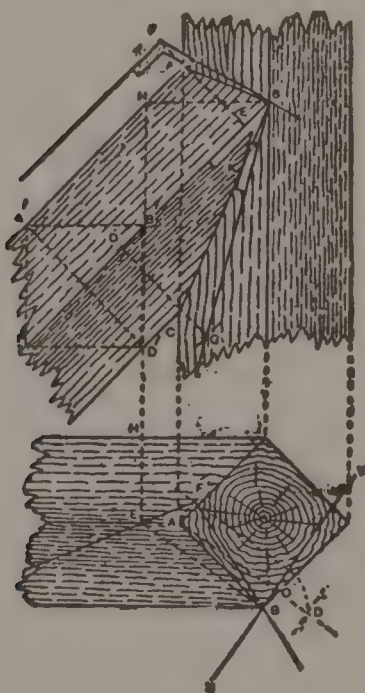


Fig. 409.

XY equal to the height of A above HB in Fig. 408. With B as a center, and D as radius, describe the dotted arc down to XY, and continue it on at right angles to meet the line AF drawn parallel to XY; the angle EFB is the bevel for the two upper surfaces, and the same as the bevel J in Fig. 408. To

avoid confusion, the bevel for the lower surfaces is not shown in Fig. 409, but is found in the manner already explained.

Fig. 410, is a section of a purlin, showing the pitch of the roof X , and the level line Y . Fig. 411 is a plan of Fig. 410, with a portion of a hip or valley rafter, making an angle of 45 degrees added, which occurs when the pitch of both sides of the roof is the same. When the pitches are different, bevels for the purlin on both sides of the hip or

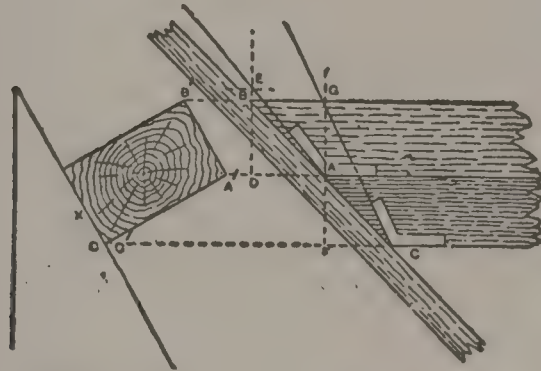


Fig. 411.

Fig. 410.

valley must be found; the angle that it makes with the pitch in the roof in plan being the only angular datum required. The method of finding the cuts is as follows: After drawing the purlin as shown in Fig. 410, draw the plan as in Fig. 411, and through the Point A, draw line FG at right angles to the edge of the purlin; make FG equal in length to AC , Fig. 410, and join CG , which will give the bevel for the wide side of the purlin. The bevel for the narrow side is found in a similar manner

by drawing DE through B, making it equal to AB, Fig. 410, and joining AE.

Fig. 411 shows all the lines necessary for obtaining the bevels in Figs. 410 and 411, the indices corresponding.

The methods shown herewith for obtaining the bevels and cuts for raking timbers of various kinds are quite simple compared with some methods taught. They are not new, nor are they original, as they have been in use many years among expert framers and millrights, and have been published, once before now at all events; the present method of rendering, however, I am persuaded, will be found simple and easily understood.

In connection with obtaining bevels of timbers that are set with an inclination, having one end resting on a floor and the other end cut to fit against a ceiling, the timber lying with two of its angles in the direction of its inclination and the other two at right angles to them.

In that case the upper end of the timber would require to be cut with the same bevels as the lower end, only reversing the bevels as both top and bottom bevels are alike.

If we consider the corner post as a prism, having four sides at right angles to each other, then when we cut the foot of it so obliquely a bevel as at ABC, Fig. 412, as to pitch it at the required inclination, the section resulting will not be square but lozenge shaped, as shown at Fig. 412, and this, of course,

would not stand over a square corner and have its sides to correspond with the face of the sills or plates, so make the post a prism so that its sides will conform to the face of the sills in the "backing" of the post. The lines to shape the post correctly to meet this condition may be obtained in several ways, but by far the simplest is shown at Fig. 413, where the square is employed to show the amount of overwood to be removed. Let us sup-

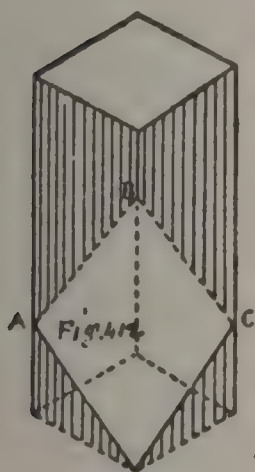


Fig. 412.



Fig. 413.

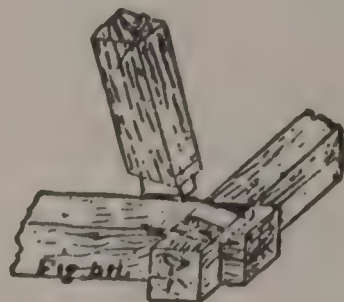


Fig. 414.

pose the sills to be halved together as shown at Fig. 414, taking no notice of the tenon and mortise which are shown in this diagram, and this will give us as a ground plan of the sills, Fig. 415, KK, showing the ends of the sills which project past the frame. The point E in Fig. 413 will correspond with the point E Fig. 415 when the post is in position, and the points C and D will correspond with C and D in the same figure. To get the lines for the "backing" draw the diagonal line AB, on Fig.

413 then place the heel of the square on the line AB, near the long corner, and adjust the square on the timber so that the blade just coincides with the corner C, then mark along the blade and tongue of the square, continuing to G and H, and these points will be the gauge points sought, showing the slabs to be removed—DG and HC.

In laying off the bevels at the foot or top of the post, it must be remembered that the outside corners of the post, AA, Fig. 413 and 415, is the working edge from which the bevels must first be taken, so when the proper bevel is obtained, either by the square or by an ordinary bevel, we must proceed as follows: Bevel over from the corner A, first on one face of the post, then on the other; then turn the timber over and continue the line across the next face to the corner, and perform the same operation on the fourth face. The lines are now complete for cutting the shoulders, but should there be a tenon on the post and a toed shoulder as shown at Fig. 414, then provision must be made for same, a matter the intelligent workman will find no difficulty in dealing with.

We will now deal with the bevels of the girts that are usually framed in between the posts of tapering structures. When the post only inclines in one direction, the problem of getting the bevels is a very simple one, as only the angle of inclination is required for the down cuts, the cross cuts all being square. With posts having two inclinations, how-

ever, the case is more complex and requires a different treatment, as all the cuts are bevels. While it is always—or nearly so—necessary to “back” the post on the outside, it is hardly ever necessary to perform a similar process on the inside corners of the post, therefore provision must be made on the shoulder of the girt to meet the condition, and this is done by cutting the shoulder on a bevel on both down and cross cuts. Let us suppose EF in Fig. 416 to be the down cut, or the angle of inclination, marked on the girt ABCD, just as the

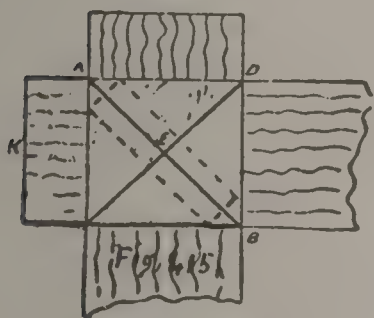


Fig. 415.

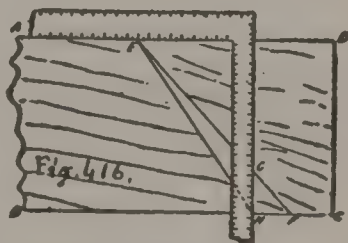


Fig. 416.

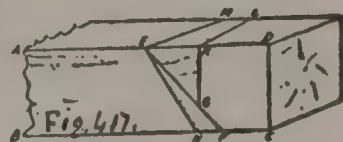


Fig. 417.

line would appear in elevation. Then from E to G, on F, set off a distance equal to the width of timber used in the girt, which would be equal to DC. Square down from the point G as shown to H, connect EH, and this line will be the bevel for the face end of the girt. This line being obtained carry a line across the top of the girt corresponding with the inside face of the corner post, and to find this line we must operate as follows: Let Fig. 417 be a reproduction of Fig. 416, then we lay the blade of the square on the line EF, and supposing the

girt to be 8 inches square, we move the square along until the point 8 on the tongue coincides with the corner of the timber, when the heel of the square will define the point G. From G square up, obtaining the point K. Square across from K to the point L, which is on the inner corner of the girt. From L set off a distance back from the post equal to the thickness of the slab that would have been removed from the post, if backed inside, which mark off at M, and from this point draw a line to E; then ME will be the bevel of the cross cut over the girt.

I have dwelled on this subject at some length because of some of the difficulties that surround it, and which in these pages I have endeavored to simplify and explain. Tapered structures of the kind discussed, whether on a square or polygon plan, are always troublesome to deal with unless the director of the work is well versed in a knowledge of the principles that underlie the construction of such structures and this means, almost, an education in itself. I have not touched on the rules for obtaining the lengths and bevels of diagonal braces in structures of this kind, as I am persuaded the sharp workman, who masters the rules given herewith, will be able to wrestle successfully with the diagonal regular tapered work.

Sometimes an irregular tapered frame is built to serve the purpose of a regular tank frame, then some changes from the foregoing take place.

If we build two frames same as shown at Fig. 418, and stand them plumb, with their faces as the illustration shows, any distance apart, there need be no trouble in framing them or in tying them together with girts, as the latter may be framed

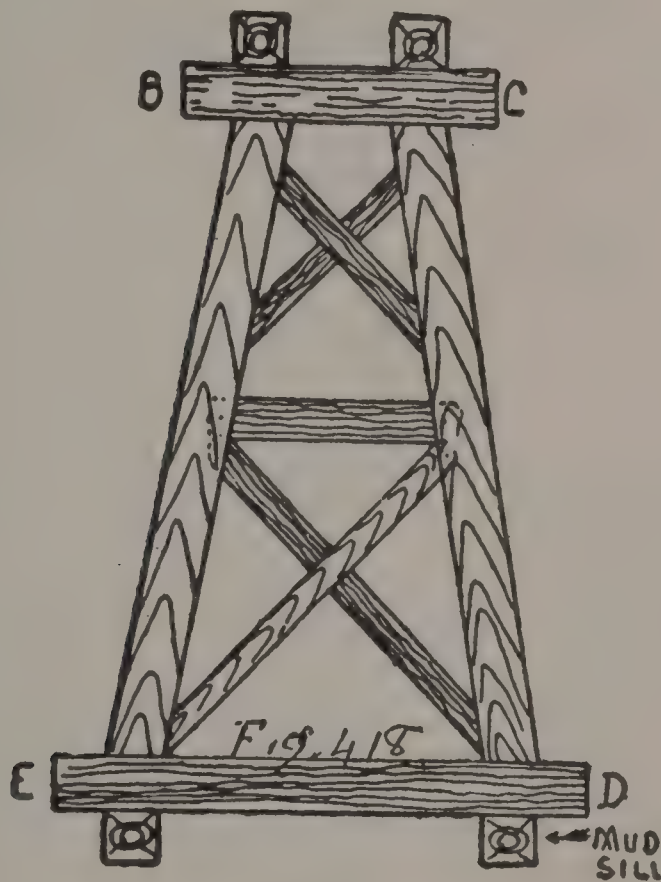


Fig. 418.

into the posts square, and the cuts or bevels for the posts and cross timber may readily be obtained from the diagram of the work. Should the two bents, however, be made to incline towards each other, new conditions arise, that make it more difficult to get the joints for the girts, and backing for

the posts. When the bents draw or lean into each other the posts have a double bevel or pitch making it take the form of a hip and as the posts are slanted over to form the pitch on the other side, we find that the face side, No. 2, Fig. 419 will draw in from the face of the sill on the corner B. The

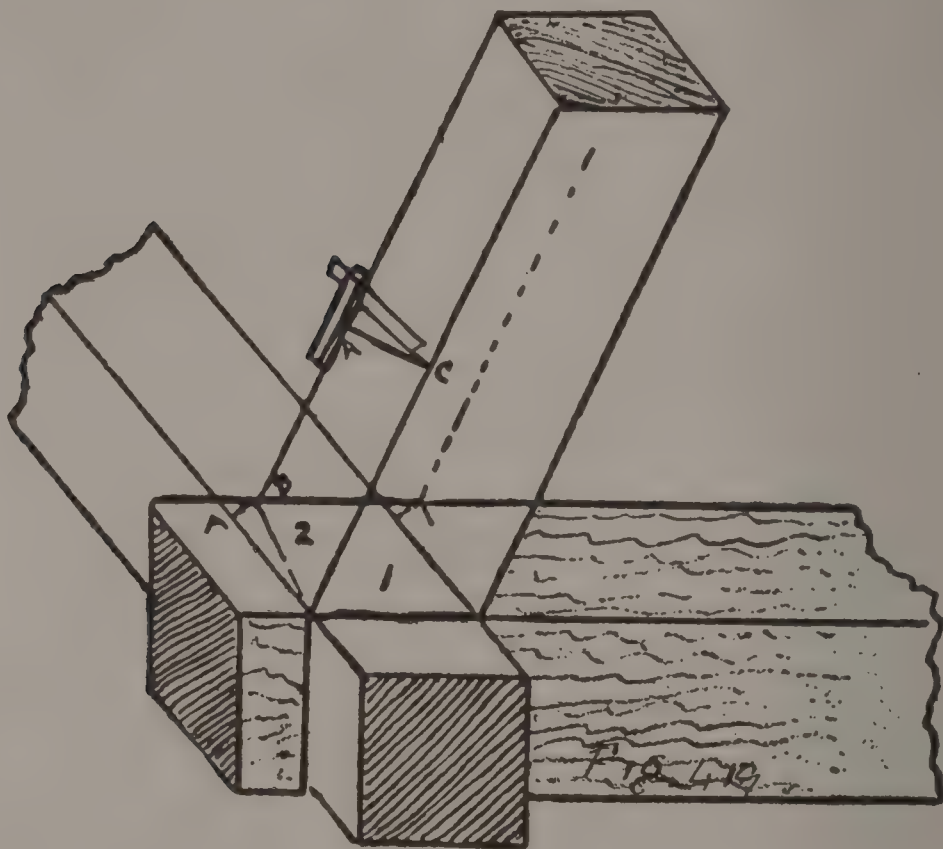


Fig. 419.

Amount the post will draw in can be determined by cutting the proper bevels on bottom of post and placing side No. 1 Fig. 419, flush with the bent sill, then square out B to A on side No. 2. The distance AB is the amount the post will draw towards the center as the bents are slanted towards each other. This distance is nothing more or less

than the backing of the hip, but the bents being framed one side on the principal of a common rafter and then leaned towards each other, forming hips at the corners, cause the backing to come all on one side as shown in Fig. 420. Side No. 2 is the side that has to be backed in order to stand flush with sill, and the amount to take off the outside corner is the distance AB. For the bevel across the top of girts and braces on side No. 2,

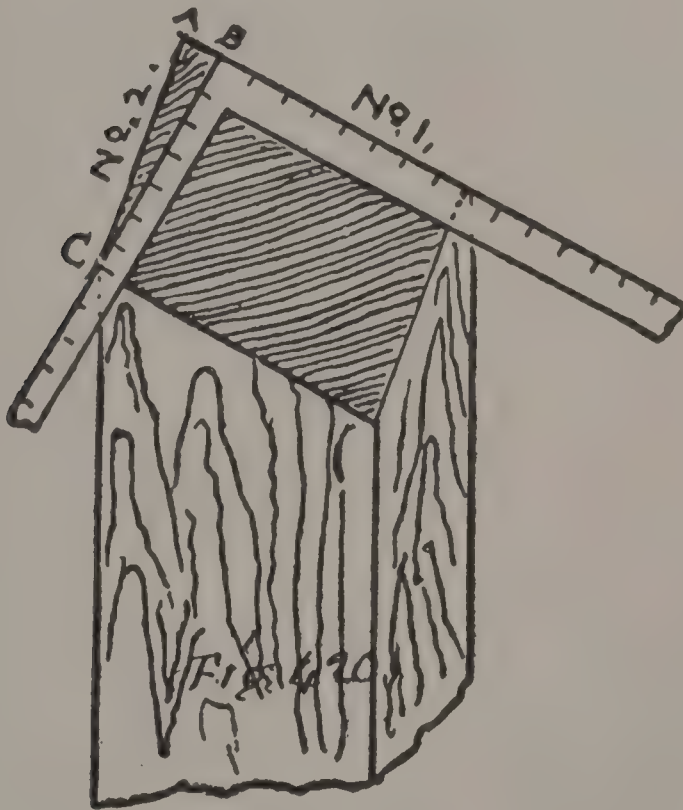


Fig. 420.

419, square across the post as AC, set off AB same as is shown at bottom of post, and connect BC. A bevel set with stock on line of post and blade on line BC will give the required bevel: blade gives

cut. The backing is perhaps more easily explained by Fig. 420. Cut a section of post to required bevels on the bottom and place a steel square flush with side No. 1 and it will show plainly the amount of backing to be taken from outside corner as ABC. These lines will not do to set the bevel by for cutting the top and bottom sides of girts and braces because AC in Fig. 420 is on the bevel of the bottom cut of hip and therefore is greater than the thickness of the post. The cut for girts and braces is the thickness of post and the backing applied as shown in Fig. 419.

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STAIR BUILDING AND HANDRAILING

PREFACE

The following pages in stair-building and handrailing are taken from the actual working drawings of practical handrailleurs and stair-builders. The first division is, in a great measure, the work of George Langstaff, New England, and is considered by expert workmen to be one of the best treatises of the kind, with regard to the stairs dealt with. Of course there are only eleven kinds of stairs, but they are so arranged that any person mastering to the full extent these eleven would find no insurmountable difficulty in dealing with stairs of other kinds.

It must be remembered that the reader of this book is supposed to have a considerable knowledge regarding the various methods of building the stair proper in all its different forms, for without this knowledge it will be impossible to understand the method of laying out and constructing a rail, even for a straight stair having a ramp at the newel post. That is the publishers' reason for including a valuable treatise on that subject, which teaches, in a very simple manner, the proper way to lay out the carcass of a stair, and all new beginners who have not obtained a fair knowledge on the subject will appreciate this addition, which, in conjunction with this work, will fully equip any young man with all the information he will ever likely require regarding the art of stair-building and handrailing.

The greater portion of the first division was published in "The Builder and Woodworker" many years ago, and afterwards, in a very much amended form, in "The National Builder," and is now in book form for the first time.

The second division which contains some excellent examples is the work of several contributors, who worked under a like system. The methods of obtaining the wreaths and twists are worth studying, as they show how these can be lined out with the greatest of ease when the subject is understood. This method is nearly complete in itself.

The third division is perhaps the most complete of the three, as about any kind of a rail can be obtained by the use of this system. While not exactly like the system of the late Robert Riddell, it approaches it so nearly that ordinary workmen would scarcely know the difference, but there is a difference, and Mr. Wilson, who has helped to work this system out, deserves much credit for simplifying the whole scheme.

The science of handrailing was never reduced to such simplicity as now, and it is claimed for the three divisions shown in "Common-Sense Handrailing" that the latest and simplest methods are shown therein, and this, too, at about one-fifth the cost of the older and more elaborate methods. In saying this we do not mean to belittle the larger and in some cases the more extended works of Nicholson, Graff, Reynalds, Sherrett, Monckton, Secor, Riddell and others. Each

and every one has much to recommend it, and the expert handrailer will no doubt have copies of these larger works on his shelves. To the first and last of the names given in the foregoing belong the greatest honors in this science, the first for his invention, or rather discovery, of the true geometrical principles involved, and the latter for divesting the science of its crudities and reducing it to more simple conditions. Nearly all improvements in the science are due in large measure to the methods employed by Robert Riddell.

The prismatic solid when thoroughly understood will show to the student pretty nearly everything required in handrailing, and it is the advice of the writer that this solid should be analyzed by the young man who wishes to become an expert, and the study will neither be tedious nor uninteresting.

In all cases a stairway should be commodious, inviting and easy of ascent, and when winders are used they should extend past the spring line of the cylinder, so as to give a fair wreath at narrow end of tread and to bring the rail as near as possible to the same pitch as rail over square steps, and when the hall or space is sufficiently wide should not be less than 3 feet 6 inches in width; 4 feet would be much better, then two persons can pass each other. The height of riser and width of step are governed by the space allowed for the stairs, but as a general rule the step should not be less than 9 inches wide and the riser should not exceed

8 inches in height. Seven inches rise and 11 inches tread make a very easy and good-looking stairway. If the width of tread is increased the riser must be correspondingly reduced. The tread and riser together should not be over 18 inches or less than 17 inches. Of course there are occasions when this rule cannot be employed, and the workman will be called upon to exercise his own judgment, but the closer he keeps to this rule the better will be his stair so far as comfort and convenience are concerned.

This little book contains over 240 illustrations—all of a practical nature—and it is hoped the text describing them is sufficiently clear, and that the student will have no difficulty in understanding what is meant and in being able, after understanding them, to construct a handrail over any flight of stairs that he may be called upon to erect. This is the ardent wish of the writer.

FRED T. HODGSON.

Common-Sense Handrailing

FIRST METHOD

The building of stairs and properly making and placing over them a graceful handrail and suitable balusters and newel posts is one of the greatest achievements of the joiner's art and skill, yet it is an art that is the least understood of any of the constructive processes, that the carpenter or joiner is called upon to accomplish. In but very few of the plans made by an architect are the stairs properly laid down or divided off; indeed, most of the stairs as laid out and planned by the architect, are impossible ones owing to the fact that the circumstances that govern the formation of the rail are either not understood, or not noticed by the designor; and the expert handrailer often finds it difficult to conform the stairs and rail to the plan. Generally, however, he gets so close to it that the character of the design is seldom changed.

The stairs are the great feature of a building, as they are the first object that meets the visitor and claims his attention, and it is essential, therefore, that the stair and its adjuncts should have a neat and graceful appearance, and this can only be accomplished by having the rail properly made and set up.

It is proposed in this little book to give such instructions in the art of handrailing as will enable

the young workman to build a rail so that it will assume a handsome appearance when set in place. There are eleven distinct styles of stairs shown, but the same principle that governs the making of the simplest rail, governs the construction of the most difficult, so, having once mastered the simple problems in this system, progress in the art will become easy, and a little study and practice will enable the workman to construct a rail for the most tortuous stairway.

A knowledge of geometry is not required in the study of this system, but it would aid the workman materially if he possessed a knowledge of that science, and where possible he should avail himself of acquiring as much knowledge of geometry as possible, not only for the study of handrailing but nearly every branch of the building trade.

The progressive lessons given herewith will, I am sure, be of great assistance to stair-builders already engaged in the business and to the young aspiring mechanic, anxious to master every branch of his trade and to penetrate all its mysteries. This system will open a hitherto sealed book, especially to the young man whose knowledge of geometry may be rather limited. There will be no labyrinthic network of lines to torment and confuse the student, nothing but what is absolutely necessary to obtain the face moulds and bevels for marking and working the wreaths. The figures from I to II show flights of stairs of various shapes and forms, and cover all the examples the workman will ever likely be called upon to build. At any rate, if he should have to construct a form of stairs not shown in these examples, the knowledge gained by a study of these presented will enable him

to wrestle with other forms, no matter what their plans may be. The only form of stair not shown that the student may be called upon to build would very likely be flights having an elliptical plan, but as this form is so seldom used, and then only in public buildings or great mansions, it seldom falls to the lot of the ordinary workman to be called upon to design or construct them. However, to provide for such a contingency a method of laying out and constructing a handrail will be illustrated and described at the close of this treatise.

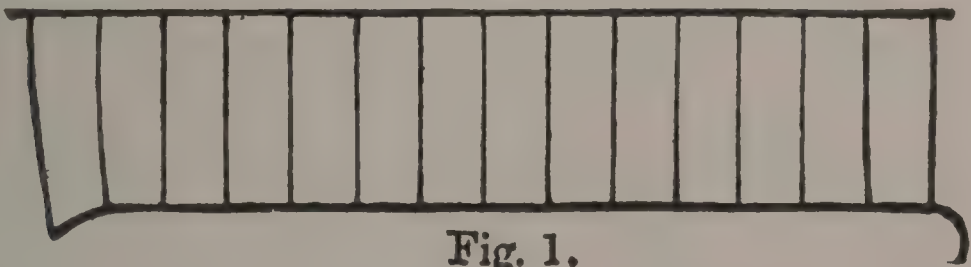


Fig. 1.

Fig. 1 exhibits the plan of a straight stair with an ordinary cylinder at the top, provided for a return rail on the landing. It also shows a lengthened step at the starting.

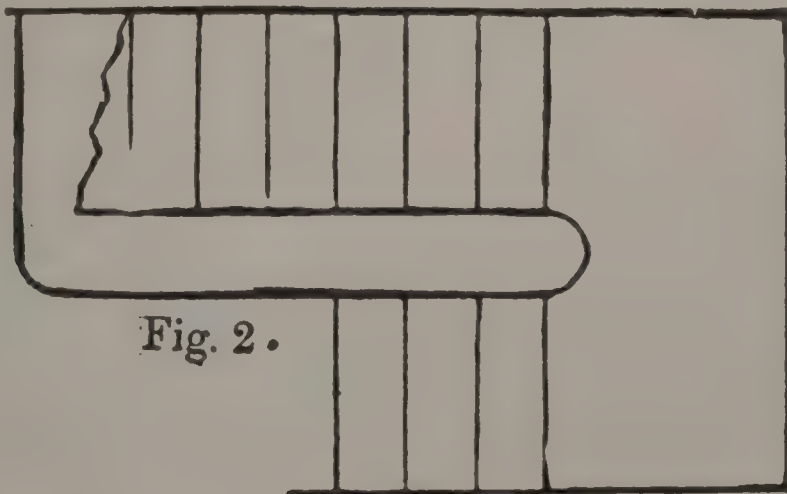


Fig. 2.

Fig. 2 shows a plan of a stair with a landing and return steps.

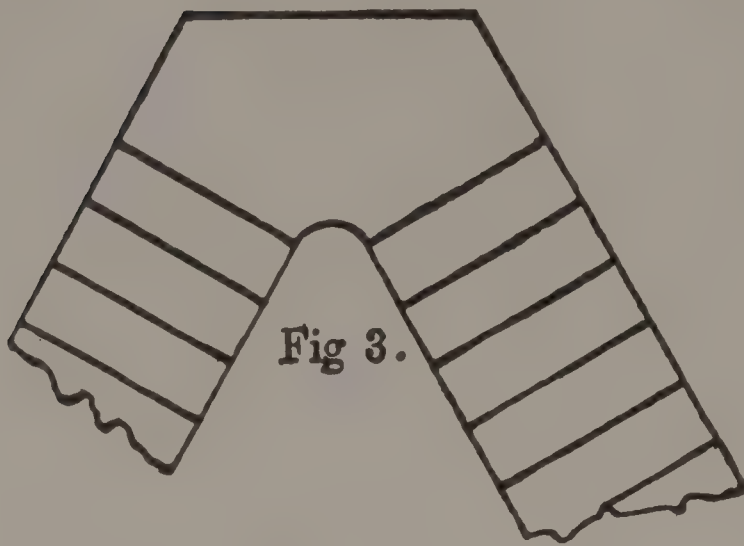


Fig. 3 shows a plan with an acute angular landing and cylinder.

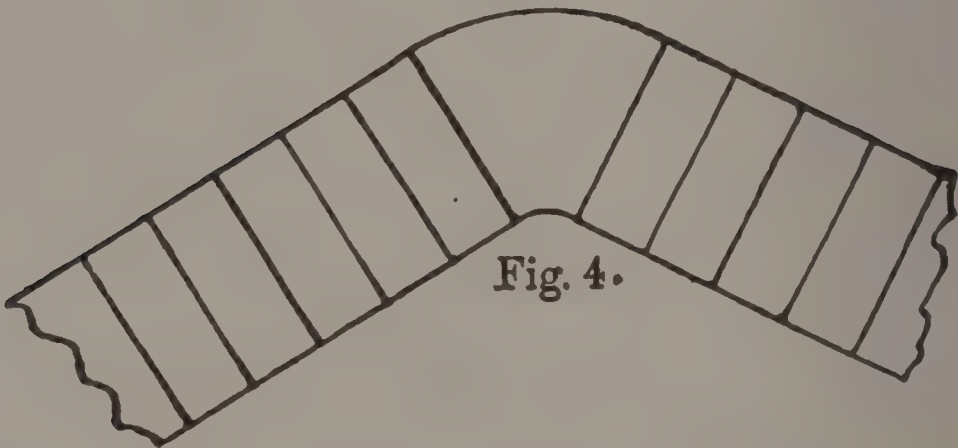


Fig. 4 shows the same kind of stair as Fig. 3, only being at an obtuse angle.

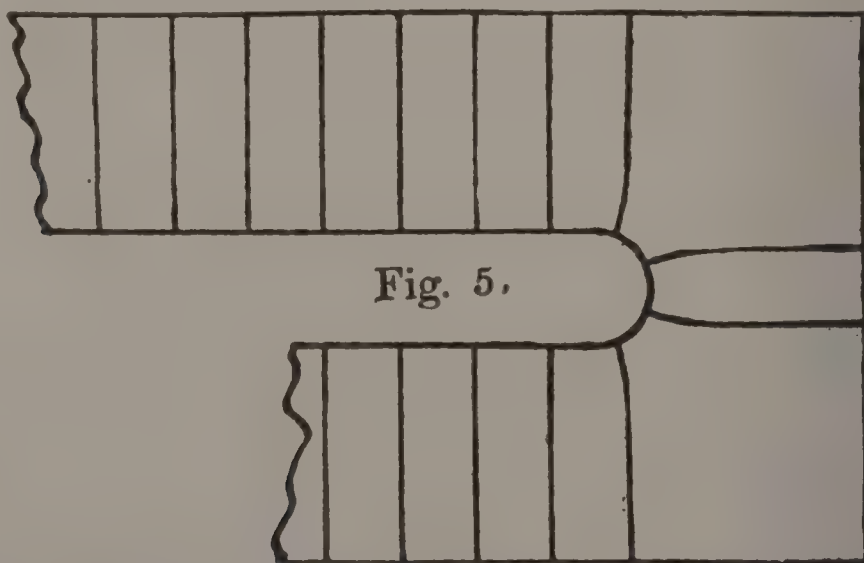


Fig. 5 exhibits a stair having a half-turn with two risers on landings.

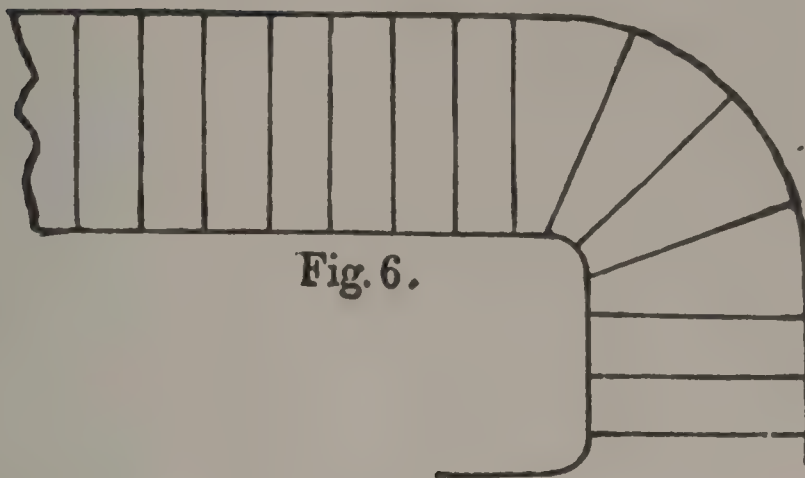


Fig. 6 shows a plan of a quarter-space stair with four winders.

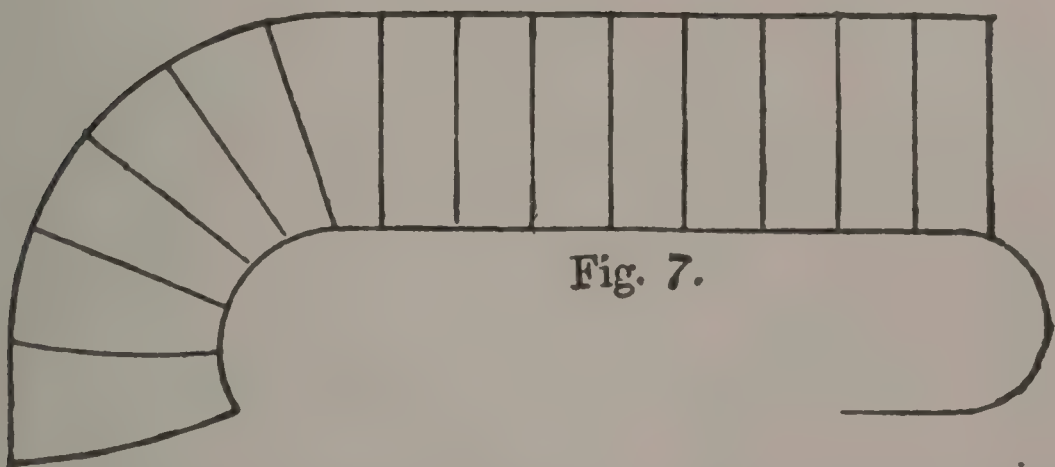


Fig. 7 is the plan of a stair similar to Fig. 6, but having seven winders.

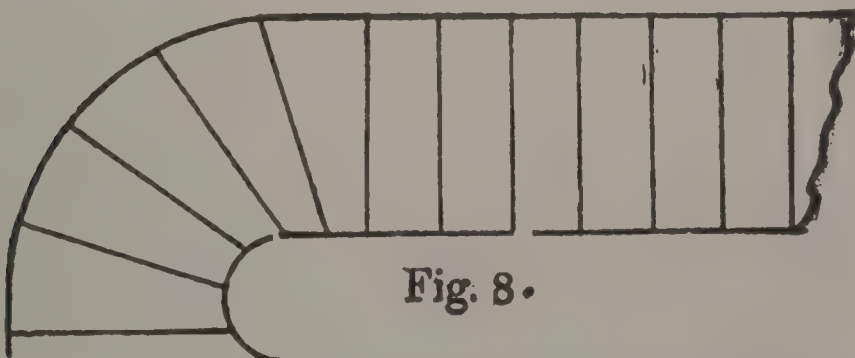


Fig. 8 shows the plan of a stair having five "dancing winders."

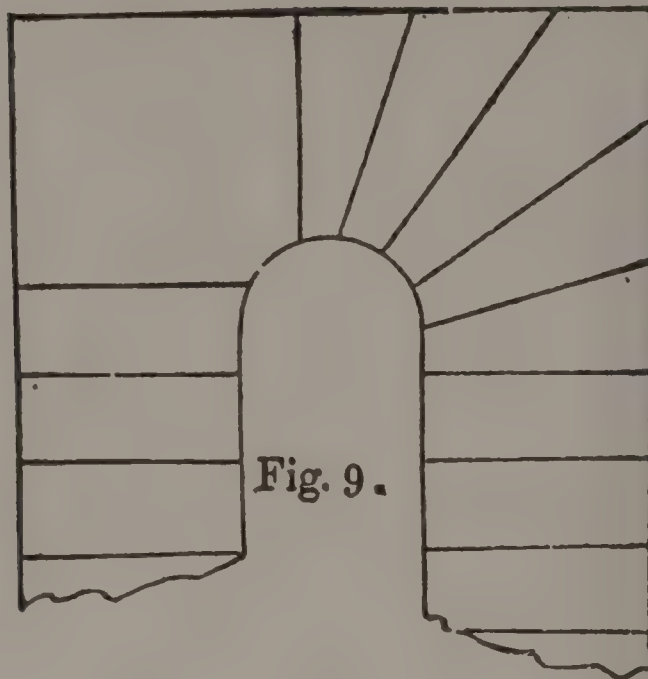


Fig. 9 is the plan of a half-space stair having five "dancing winders" and a quarter-space landing.

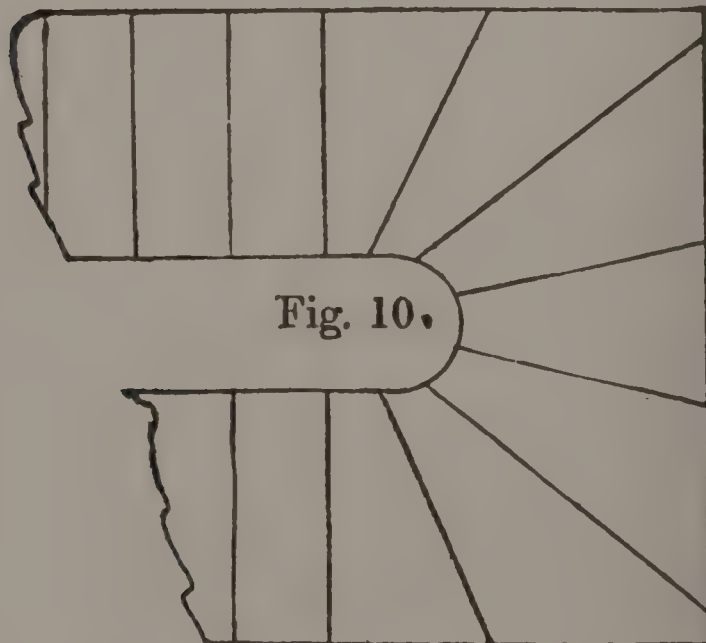


Fig. 10 shows the plan of a half-space stair with "dancing winders" all around the cylinder

Fig. 11 shows the plan of a geometrical stair having winders all around the cylinder.

As it is necessary the student should be acquainted with the methods of development of the angle of tangents which give shape and joints of

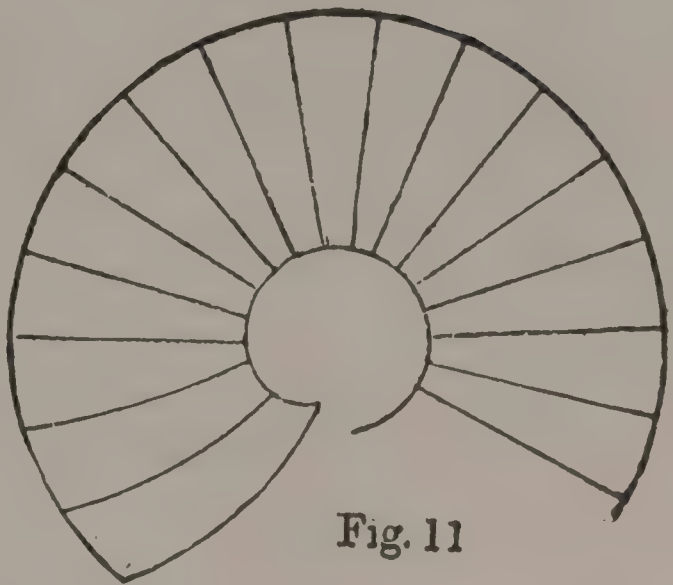


Fig. 11

the face moulds directly from the pitch lines, a couple of examples are herewith illustrated. Fig. 12 shows a straight pitch in which both tangents are of equal length, while Fig. 13 shows the tangents of unequal lengths and different pitches, and I advise the student to thoroughly master these two problems by frequently reproducing them, as these two examples are the very foundation of the system we are about to submit.

A tangent is a line touching a circle at right angles to the radius as shown at Fig. 14, and is readily constructed and as easily understood.

To construct Fig. 12, from center O with the radius OA , describe a quarter circle, APC ; draw tangents AB and CB , join AC ; through the point B draw a straight line parallel to AC ; with center B , with radius BA , describe the arcs AD and CE ; at the point E erect the perpendicular EF at right angles to DE to any desired height (in laying out a handrail this height will be the same as the height of the number of risers contained in the wreath); let F be the given height (this being one pitch); join FD , extend OB to G ; from G draw GH at right angles to FD ; make GH equal to

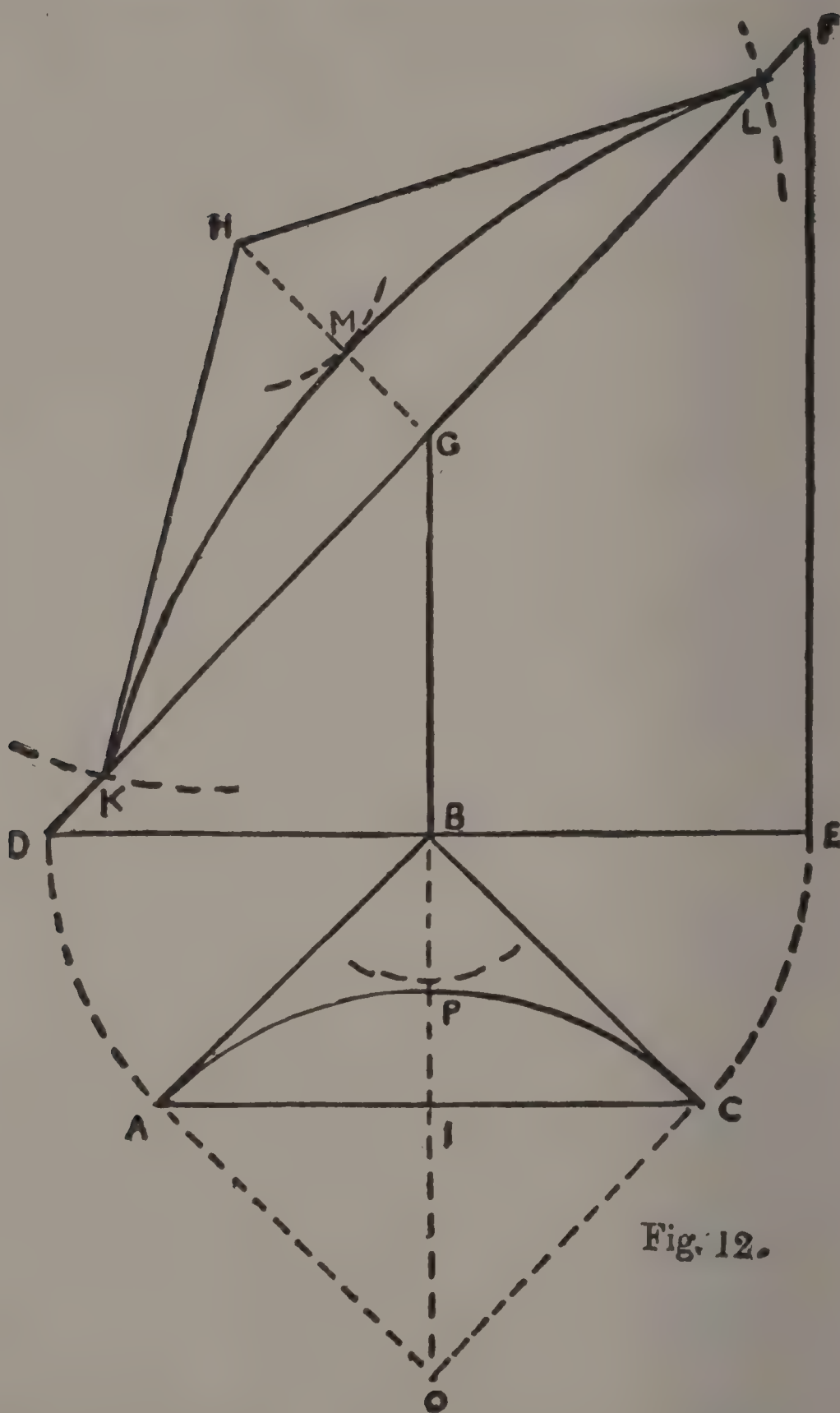
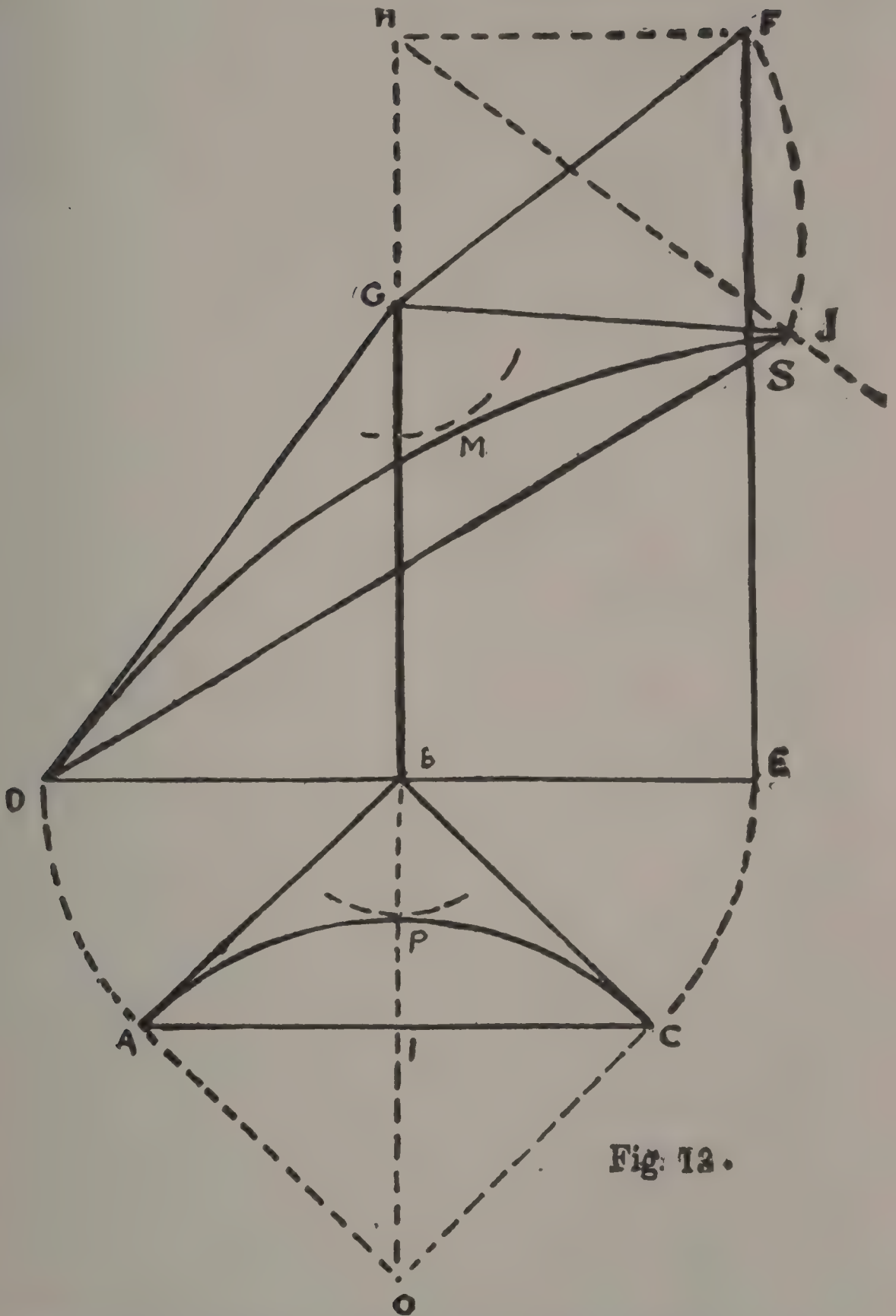


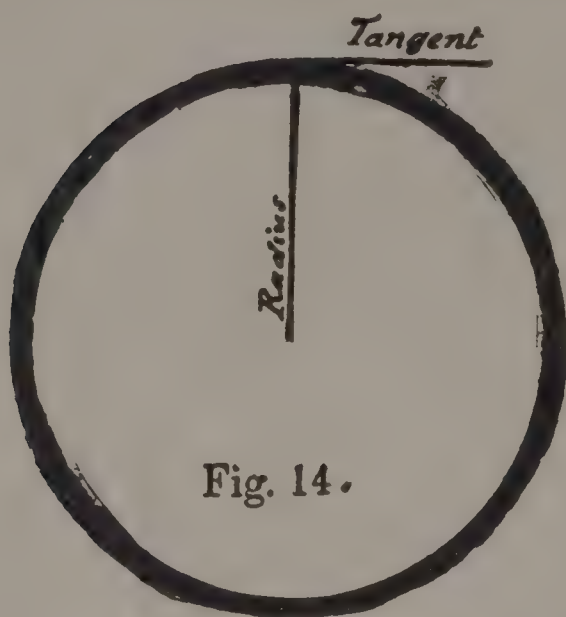
Fig. 12.

BI. With the center H and radius DG describe arcs, cutting DF at K and L; draw HL and HK, which are



tangents on the pitch, and which, when placed in position, would stand plumb over ABC.

To construct Fig. 13, proceed in the same manner as in Fig. 12, until the height is located. It will be



noticed that in this example BG is lifted higher, making the pitch-lines and tangents FG and DG of unequal lengths. To obtain the angle continue BG to H, making BH equal to EF; from H draw the line HJ to any distance at right angles to DG. With the center G and radius GF describe an arc cutting

the line HJ at S; join SG and SD and the angle is completed.

An easy way to prove the correctness of these problems is to draw them on common thick paper or cardboard on a larger scale than shown in these diagrams; then take a knife and cut out the angle DEF, place it perpendicularly over ABC, bringing D over A and E over C; then cut out the angle HKL, and if drawn correctly it will lie on the pitch-lines and fit the sides exactly.

To draw the curve line in the most practical way take B as a center, and with radius BP describe an arc touching the curve APC in the angle ABC; from H as a center, with the same radius, describe an arc cutting HG at M; then take a thin flexible strip of wood of an even thickness, bend it until it touches the points KLM; mark around it with a pencil, and the curve is completed, and near enough to absolute accuracy for all practical purposes. The curve so obtained in its perfection should be a portion of an ellipse, which it will be if correctly drawn.

Let us now go back to Fig. 1 and describe the method for obtaining the face moulds and bevels of turnout and wreath pieces for that style of a stair.

To build these stairs correctly and with an easy, graceful rail, two or three things must be carefully observed in taking dimensions and laying down the plan. Measure the height from top of first, to top of second floor; set the rod you measure with plumb at the trimmer where the stairs land, and be sure that the lower end is level from where the stairs start. Measure the width of opening from studding to face of trimmer, also the depth of joist, that the cylinder may curve round and meet the face board level; plumb down from the header at landing, and measure back the amount of run where the stairs start; divide the height into the necessary number of risers, space off the run, making one less than in dividing the height, and also make allowance for the cylinder, landing and swell of the turnout steps. Where it is practicable make the rise seven inches or as near to it as possible, and make the tread, or step, ten inches or as near as can be, as this combination makes a very easy stair for dwellings, but of course the height of riser and width of tread will be dependent to a great extent on the surrounding conditions.

In laying out the steps for the turnout observe the same rule that applies to all winding stairs, that is, to make them as near the width of the straight treads as possible on the walking line. Locate the landing riser exactly half a step from the center of rail on landing, as shown at Fig. 15. This will bring the rail the same height on landing as it is in the middle of the step. Any departure from this rule will either change the

height or will make it necessary to spring the wreath or slab off the shank, a very clumsy experiment.

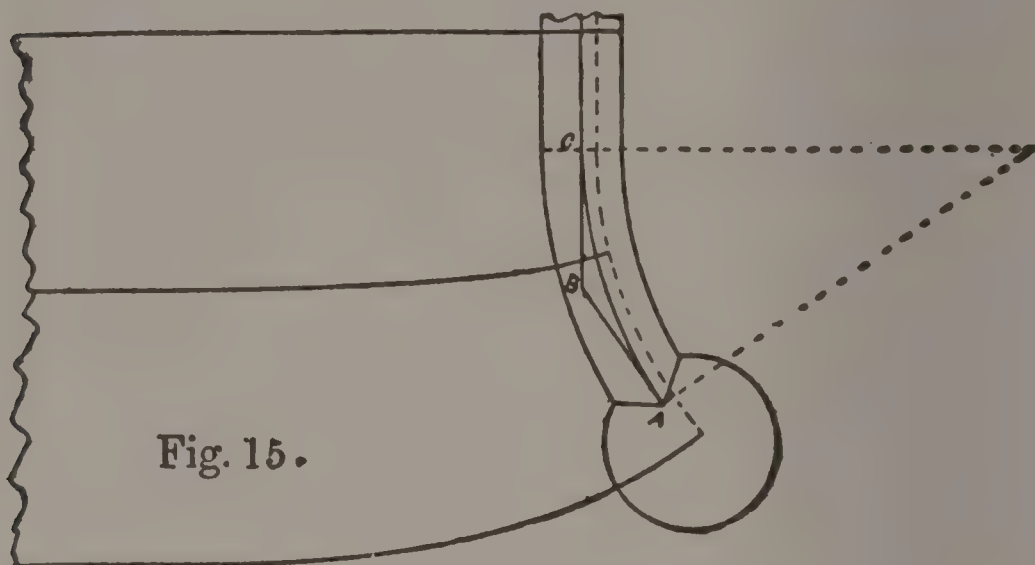


Fig. 15.

Fig. 15 shows the plan of turnout steps, with rail mitering into cap. The dotted curved line shows face of string. The black line shows center of rail with tangent ABC at right angles to dotted radius.

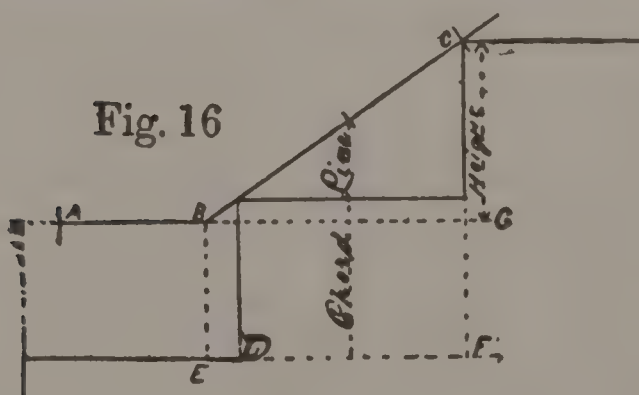


Fig. 16

Fig. 16 shows the tangents in position on the pitch. To construct Fig. 16, take the pitch-board and mark out the steps as shown. Beginning at third riser and coming down, draw

pitch-line CB from second riser D; mark distance DE, which gives angle B; draw level tangent BA, agreeing with BA, Fig. 15; continue line of first step with dotted line to F, draw FC; continue the line AB to G. The distance from G to C is the required height, and EB gives the height to which the rail is lifted at the newel.

To construct Fig. 17, draw tangents ABC, and curve line exactly like Fig. 15. In practice this figure can be drawn on Fig. 15, and to avoid confusion of lines it is transferred. Continue AB to D; draw DC at right angles to DB; set up the height, GC, Fig. 16. Connect ED at right angles to ED, draw DF; with D as center, describe an arc from B to G and from A to F, then connect EG; draw dotted ordinates AA to mark center of curve and chord line.

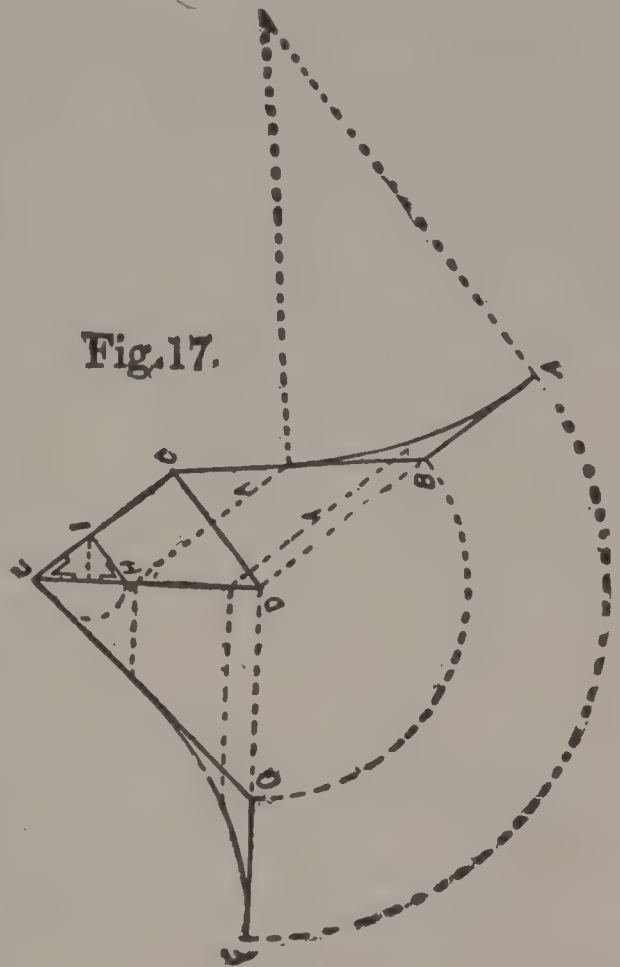


Fig. 17.

The spring bevel for squaring the wreath at lower end is found at angle E. To obtain the bevel for upper joints take a center anywhere on line ED, describe an arc touching EG and cutting ED at H. Draw line from center of arc at right angles to ED, cutting EC at I. Connect HI, and the angle at H is the upper spring bevel.

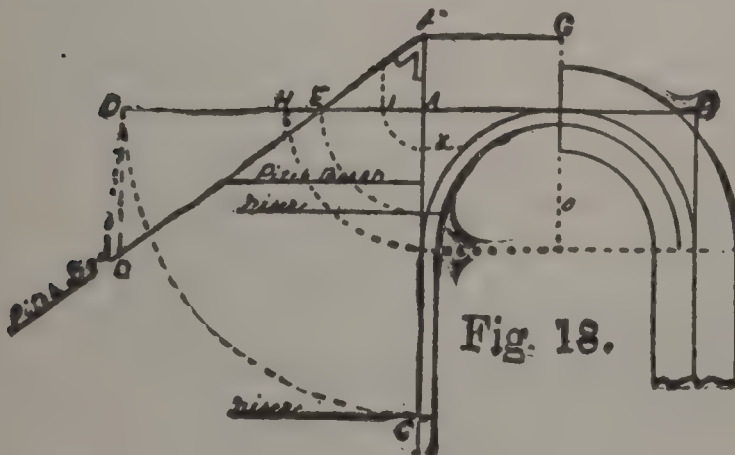
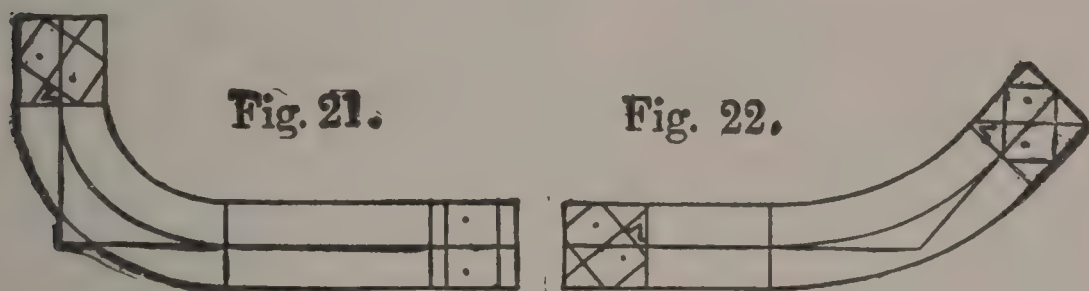


Fig. 18.

The development of pitch-line for wreath is shown at Fig. 18. First make a plan of the cylinder; draw center line of rail with tan-

enclosing the templet, and it will be seen at once how wide the mould should be and what thickness of plank is required. This method is seen in application of bevels at Figs. 21 and 22.

Fig. 20 shows the bevel portion of wreath; a better appearance is given to the wreath by using plank half an inch thicker than the rail, and casing it up from center joint as shown by the sections on end of mould.



Figs. 21 and 22 show the application of the spring bevels and templates for squaring the wreaths.

The bevel for Fig. 21 is found at F, and is simply the pitch of the stairs. The bevels for the turnout wreath are both applied in the same manner, from the inside, or the face cutting through the center, as shown by the sections.

The following illustrations exhibit a method of obtaining the face moulds for the flight of stairs shown at Fig. 2, which is a flight the most common in use.

To obtain dimensions make the plan, etc., and follow the instructions given for Fig. 1. Where the risers are located half a step from center of rail, as explained previously, the same method will apply to this flight, and the bevel will be the pitch of the stairs at the center point, and the section will be square with the face of stuff at the straight end of wreath.

Suppose Fig 23 to be the ground plan of cylinder, with risers placed in a position that insures an easy,

graceful rail, and also adds to the run by curving the landing and starting risers back to the platform.

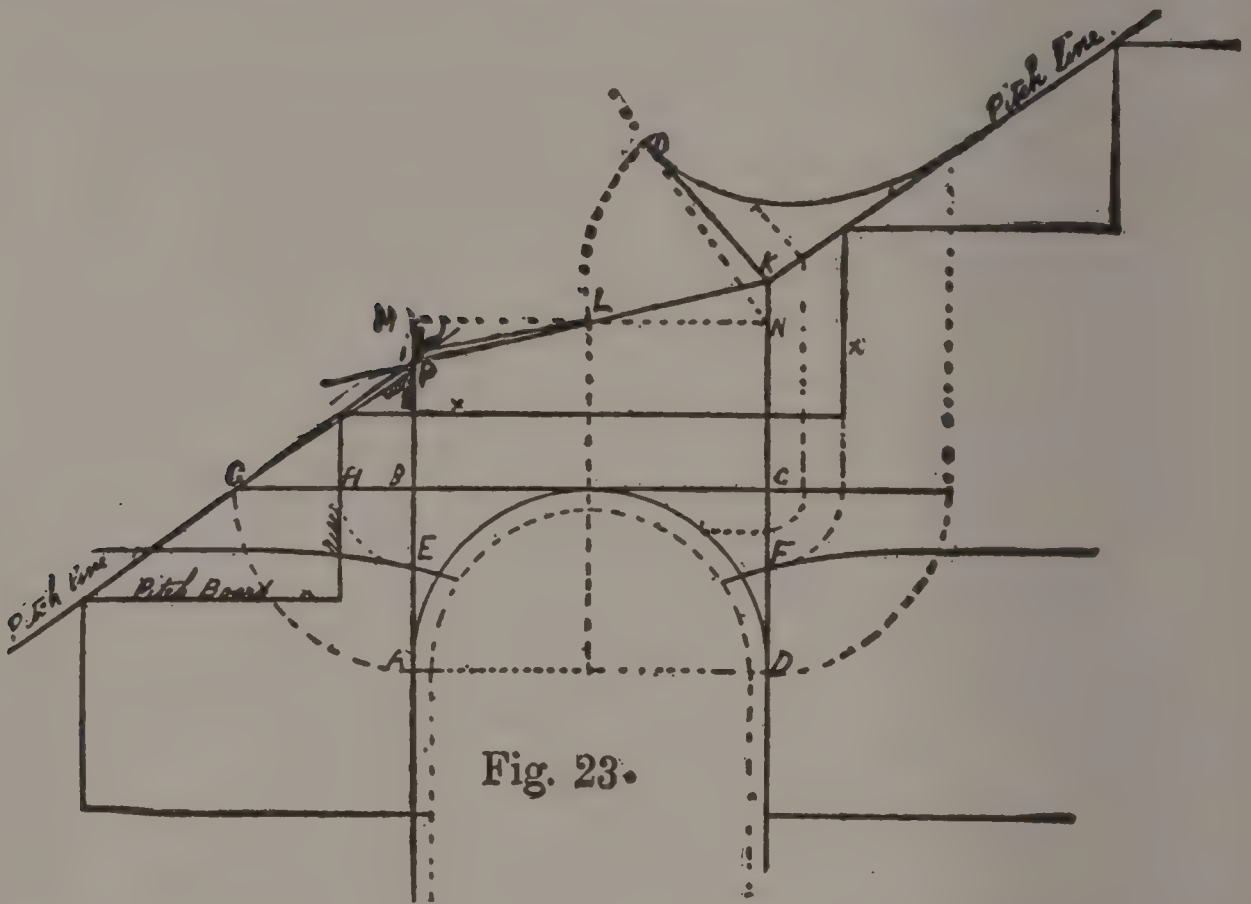
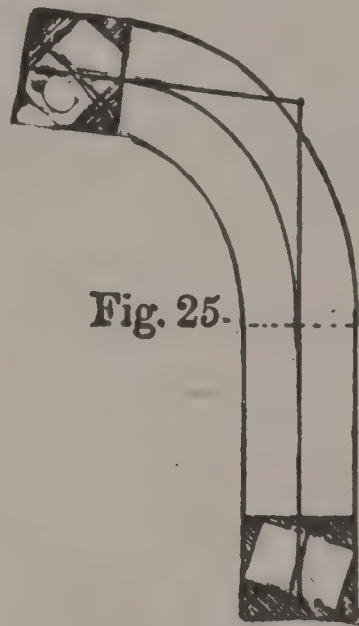
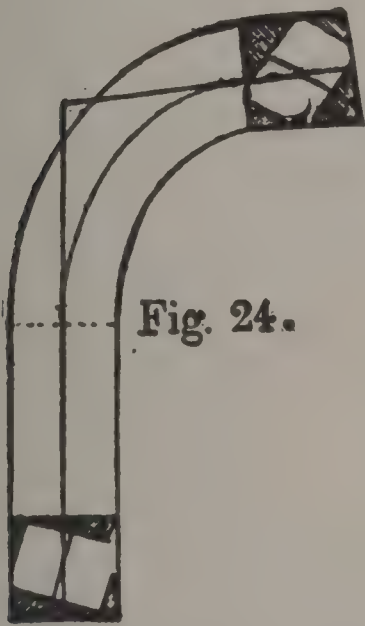


Fig. 23.

To construct Fig. 23, draw the center line of rail and tangents ABCD; from B and C as centers, swing around A and D, cutting B and C extended; swing around the risers E and F in like manner; place pitch-board with riser parallel to AB and touching H, and the raking side, cutting through G. Mark out the treads and risers as shown at XXXX. Draw pitch-lines, as shown, cutting AB and DC extended up; join IK, and the pitch-line is complete. To obtain the angle of tangents at K draw dotted line from center of cylinder cutting IK at L. Draw MN through L parallel with BC. At right angles to upper pitch-line draw dotted line NO. From center K swing around KL to O; connect KO, and the angle is complete.

To obtain the spring bevels—from center B describe an arc, touching the pitch-line KI extended, and cutting BI at P; connect PG, and the bevel for center joint is found at P.

To obtain bevels for joints connecting with straight rail, take M as a center and describe an arc touching lower pitch extended connect with L, and the bevel is found.



Figs. 24 and 25 show the sections and application of bevels on rails. Fig. 24 is the lower and Fig. 25 the upper wreath; the same face would serve for both, as the upper and lower pitches are the same.

Let us now examine Figs. 3 and 4, and endeavor to form rails to suit them. As before stated, these two examples represent on the ground plans obtuse and acute angles at the return landings; and in the formation of rails to meet the requirements for these stairs, the student will have covered the ground for the formation of rails for nearly every kind of rail required for a platform stair. In locating these risers at the landings be sure to place them, if possible, exactly

half a step each way from angle B, Fig. 26. This will insure an easy rail

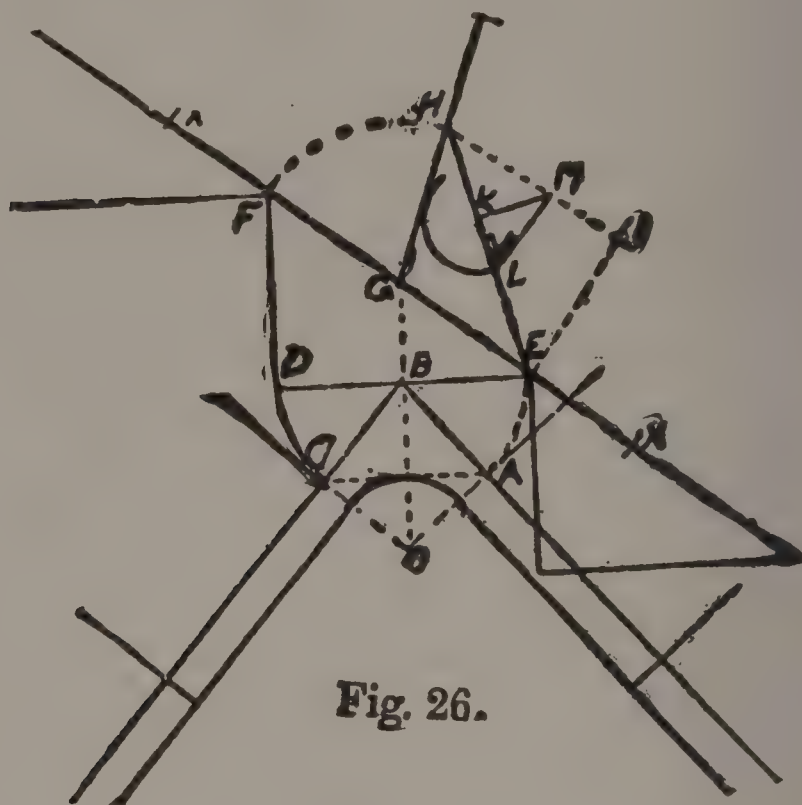


Fig. 26.

Fig. 26 shows the development of the angle of tangents for the face mould and the bevel for springing the wreath. Draw the angle ABC on center line of rail as shown; draw dotted line from center O to B; draw DE at right angles to OB; from center B swing around A and C to D and E; set up one riser from D to F, and one down from E; mark one step above and below the pitch-board; draw pitch-line XX.

Connect CA, and continue OB to G; with B as a center, describe an arc touching CA; from G as a center with the same radius, describe an arc; from E draw line touching this arc; from G again swing around GF to H; connect GH, and the angle of tangent is complete. The amount of straight wood on wreath is shown from E and H to the joints XX.

To obtain the bevel it is first necessary to find the

point I; from H with FD for radius, swing an arc and intersect with another from E; having CA for radius, connect EI and HI; take a center, K, anywhere on the line EH, draw an arc touching GH and cutting EH at L; square down from K, cutting JH at M; connect LM, and the bevel is found for both joints of the wreath, the pitch being one straight line. Fig. 27 shows application of bevel to wreath.

Figs. 28 and 29 are simply a repetition of Figs. 26 and 27

excepting that the ground plan forms an obtuse angle.

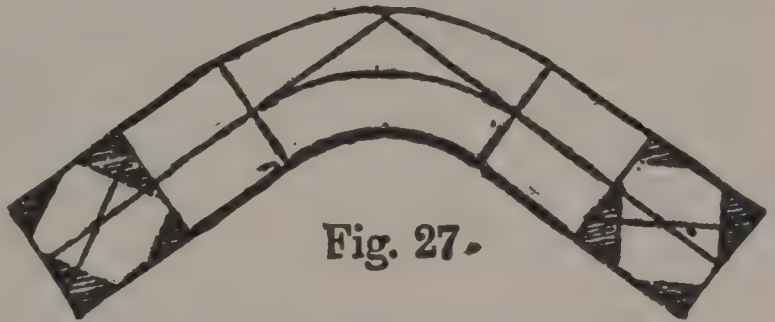


Fig. 27.

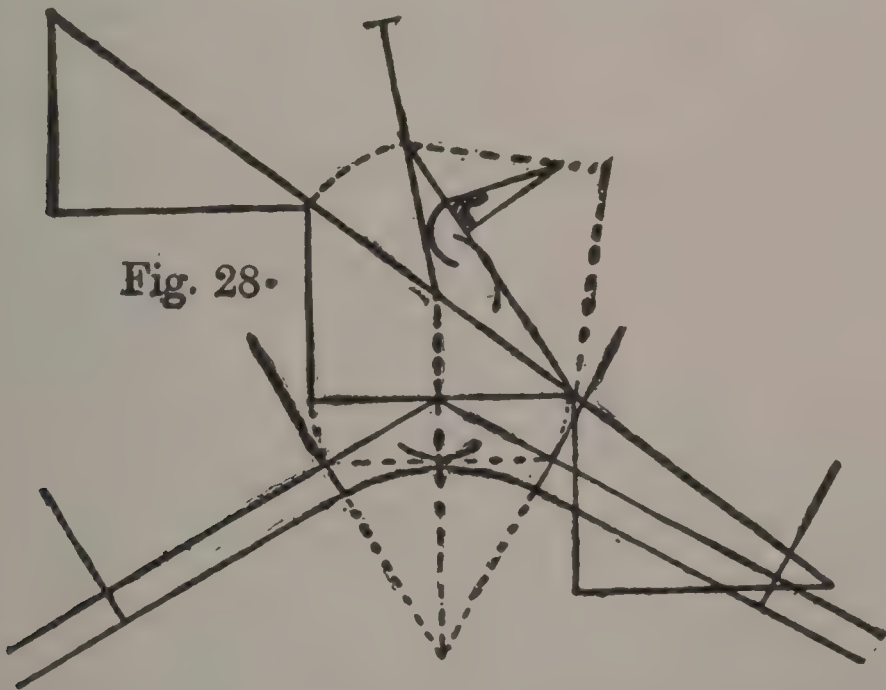


Fig. 28.

Fig. 30 shows the manner of sliding the mould on the wreath to mark it for blocking. We may state here that there have been worked some hundreds of rails during the past thirty years by this method, and we have come to the conclusion that the easiest and

quickest way to block out a rail is to use just such

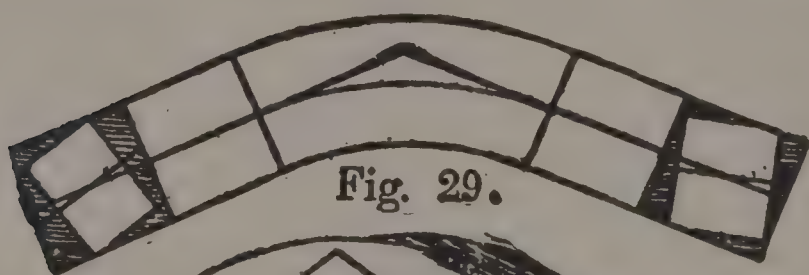


Fig. 29.

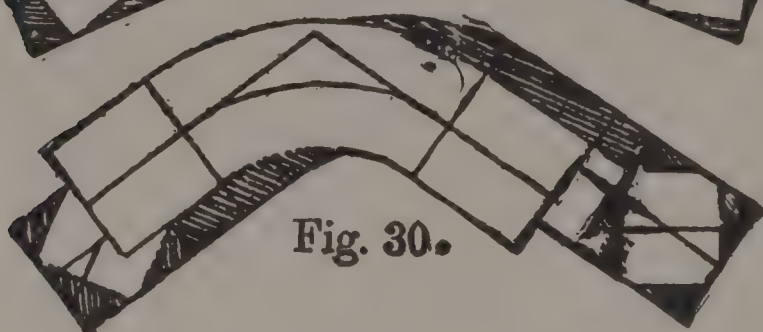


Fig. 30.

moulds as are shown in the drawing, viz., of a parallel width, and just sufficiently large to square the rail properly for moulding.

When the

wreath is sawed out, the face of stuff carefully planed true, the tangents marked and the joints made perfectly square with the face and with the tangents, then square the tangent across the joints, mark the center and draw the bevel across, as shown in Fig. 27, mark the section of rail at right angles to bevel. The best method of doing this is to use a thin templet with a small hole in the center, through which put a scratch awl, then swing the templet until exactly at right angles with bevel and mark all round it. The section being marked, square in from the joints on all sides to make sure the wreath will bolt on to the straight rail and form a clean line. To mark the curve line slide the mould up, as shown in Fig. 30, mark the inside edge (this line will not be quite as accurate as one made from an elliptical mould on the sliding principle with wide ends, but it is near enough for all practical purposes) by roughing out the inside first and occasionally planing through the wreath. Looking in the direction of a plumb-line, it will be seen at once when to take off the superfluous wood, and with a little care the inside will soon show a clean, true

surface. As soon as this is done gauge the wreath to a width, then bend in a thin strip. Connecting the straight lines squared in from each end, mark around the outside in the same manner, mark off the top, gauge to a thickness, and the wreath is squared. The plumb-line can be marked on the inside of the wreath, and will give the line of sight by taking the bevel from the angle EHJ, Fig. 26.

Now we will describe the method for constructing the face moulds of a handrailing for a stair suitable for the plan shown in Fig. 5. In this example two problems are used to obtain the development of tangents, bends and twists of the rail.

Let Fig. 31 represent the ground plan of cylinder with the risers marked in position, also the elevation and "pitch" inclination of center line.

It will be noticed that the pitch-line is perfectly straight. This is caused by the risers being placed so as to bring them exactly the width of a step from each other on the tangent line, as shown in the plan and elevation, Fig. 31. This is a point the student should always bear in mind; locate the risers this way whenever practicable, and you are sure to have a good-looking, easy rail.

To construct Fig. 31, the plan of cylinder being made with risers and center line of rail drawn, swing out A and D to meet BC extended, also the risers E and F; place the pitch-board at the point where E cuts the line BC, keeping the risers parallel with BA, and the raking side cutting through the point where A swings around to BC. Mark the step and riser and continue the elevation as shown; draw the pitch-line, draw GH, continue DC to L, draw MN at right angles to GH and extend to chord line at S; from N at

right angles to pitch-line draw a line indefinitely; with **L** for center and **LH** for radius, describe arc cutting

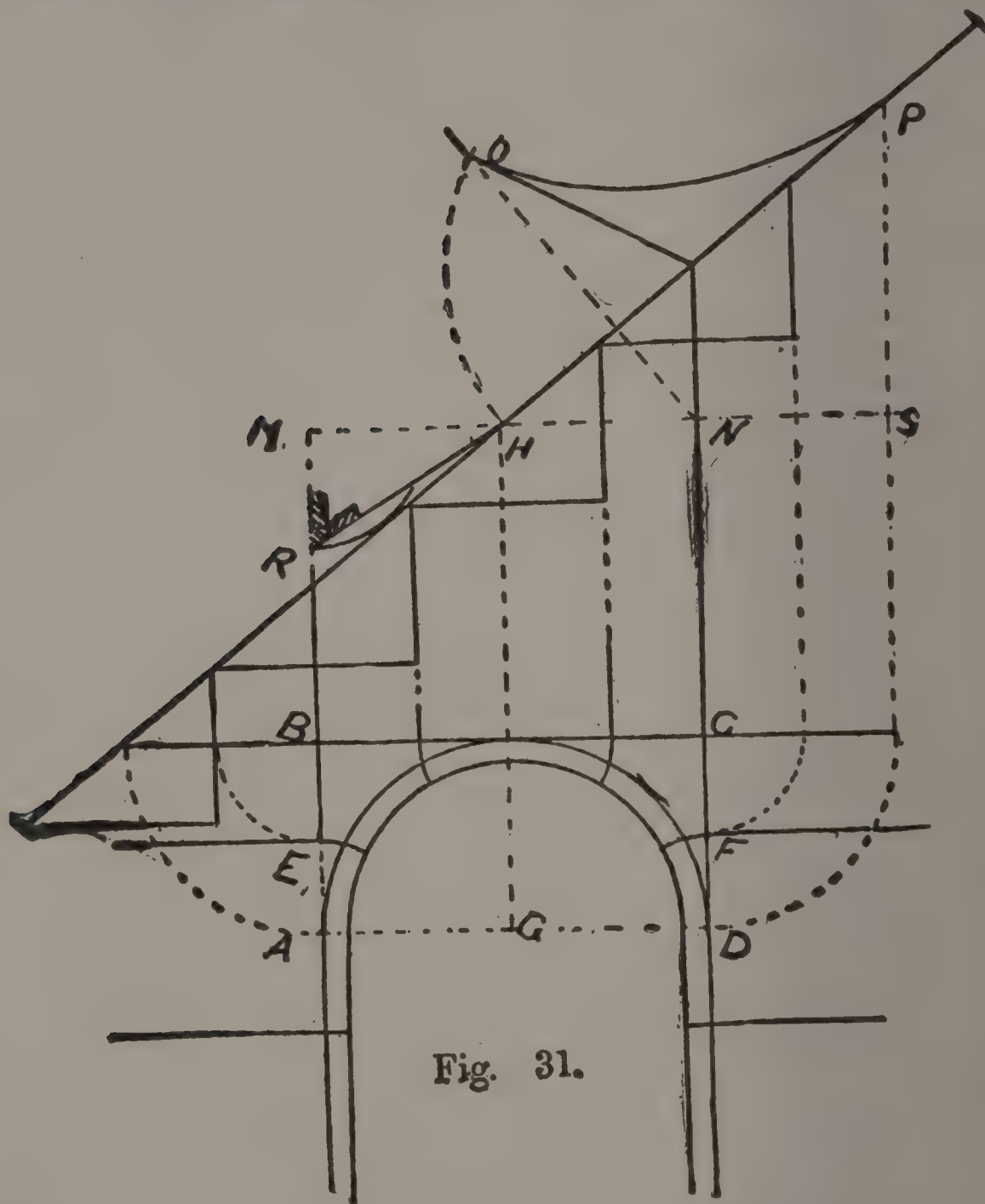


Fig. 31.

line drawn from **N** at **O**; connect **LO**, and the triangle **OLP** gives the tangents for the face mould.

The pitch-line being straight, the tangents are all of equal lengths, so it will be seen at once that the face mould obtained will be the same for both upper and

lower wreaths, and the bevel for both ends is found at R, as shown.

Fig. 32 is similar to Fig. 12, excepting the development of tangents, which it will be observed is obtained somewhat differently.

Fig. 33 describes how the development can be obtained by the method shown in Fig. 12. While this method is perfectly correct in all cases where the tangents are of equal lengths, still it is better to use the methods shown in

Figs. 32 and 34, as they will be more correct whenever a change occurs in the pitch. Fig. 34 is a facsimile

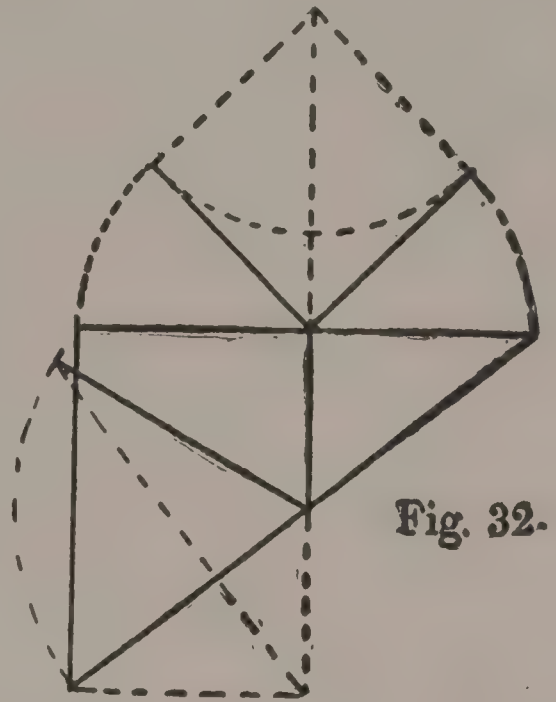


Fig. 32.

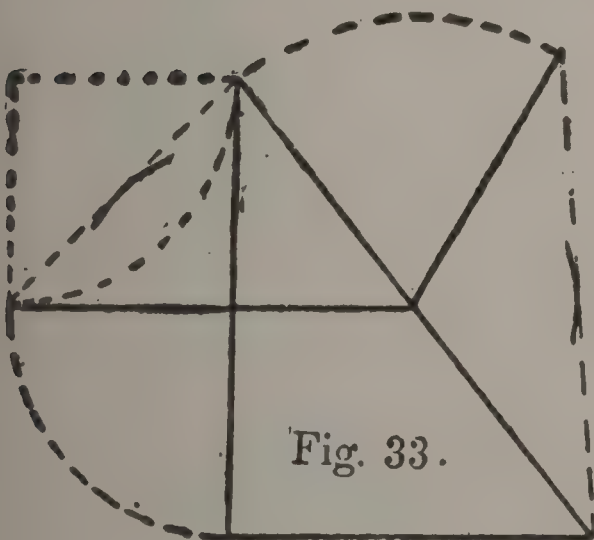


Fig. 33.

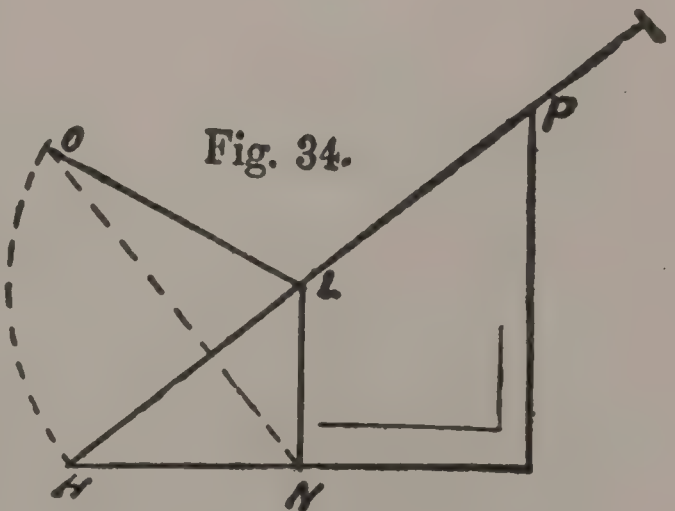


Fig. 34.

of the "development" in Fig. 31, and is drawn in order to make the student more familiar with this important problem.

In order to produce the face moulds, bevels, etc., for the flight of stairs exhibited in the plan, Fig. 6, we must proceed as follows. Fig. 35 shows the ground

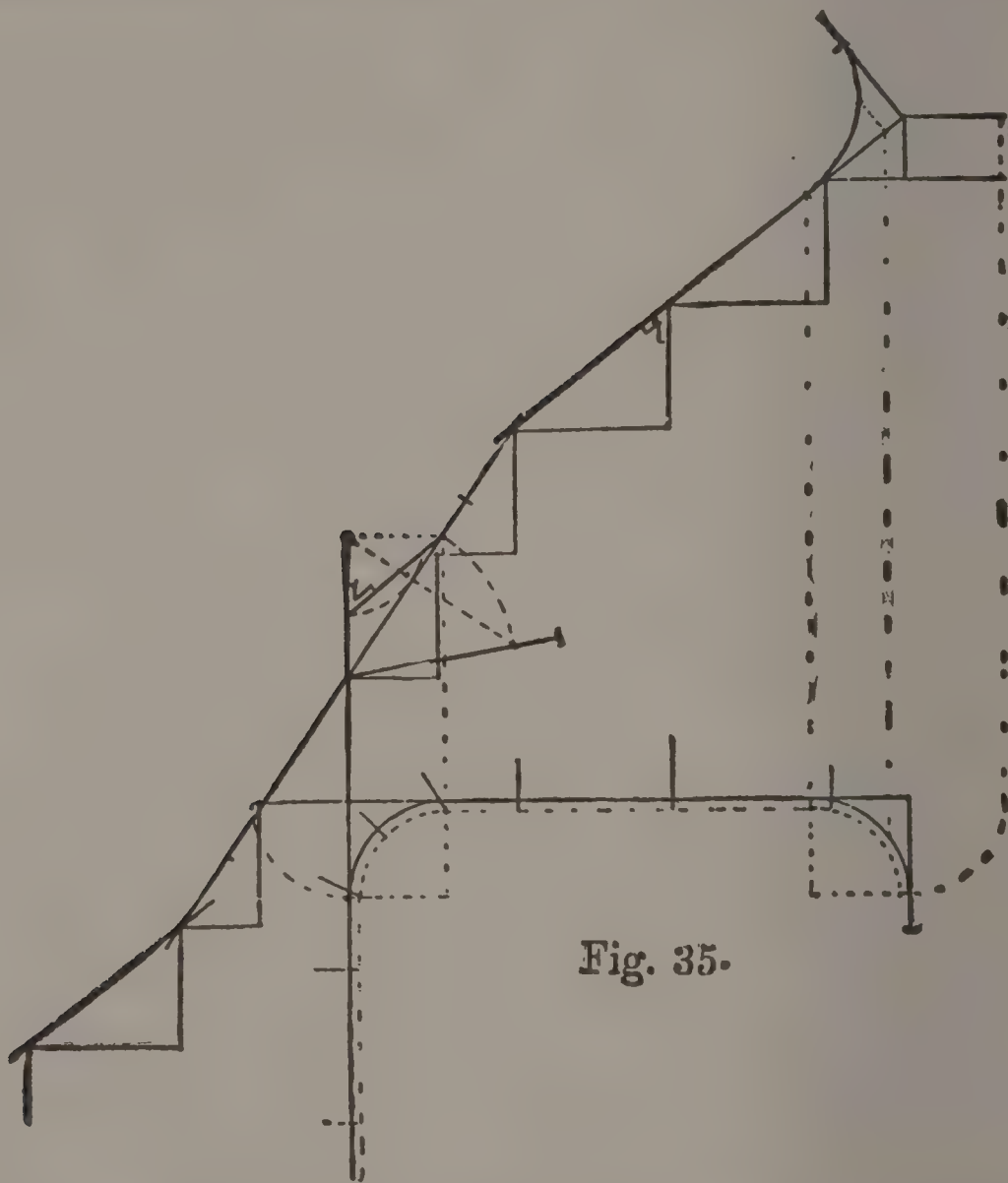


Fig. 35.

plan and elevations of treads and risers. The explanations given for the solution of previous examples will apply to this one if the figure be properly studied, as the method of proceeding to lay down the rail is exactly the same.

In the elevation it will be seen that one pitch is employed for the wreath and the connections made with the pitch of the flyers by a ramp above and below.

One pattern answers for both ramps, as the pitch over the flyers is the same in both cases.



Fig. 36.

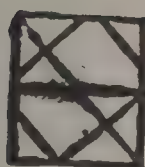


Fig. 37.

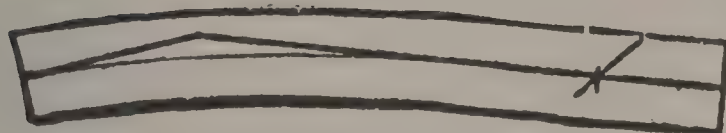


Fig. 38.

By carefully studying Fig. 12, the landing wreath, Fig. 36, will be easily understood. Care must be taken to locate the last riser as near half a step from the level tangent as possible.

Fig. 37 shows tangents, center line of rail and the application of the bevels for the wreath.

Fig. 38 shows pattern for lower ramp, and is simply reversed for the upper.

These examples are simple and ought to be readily digested by any workman who has ever had the least experience in stair-building. The young student who has never helped to build a stair or erect a hand-rail should master these simple problems (on paper) and the first opportunity that offers to see a flight of stairs and handrail set up he should embrace it, and

the whole mystery of handrailing will disappear at once.

Figs. 39, 40, 41 and 42 represent the method of drawing moulds for flights of stairs similar to Fig. 7. Starting with winders in a quarter circle, Fig. 39 shows the ground plan of risers, also tangents around center line of rail, and their development. To con-

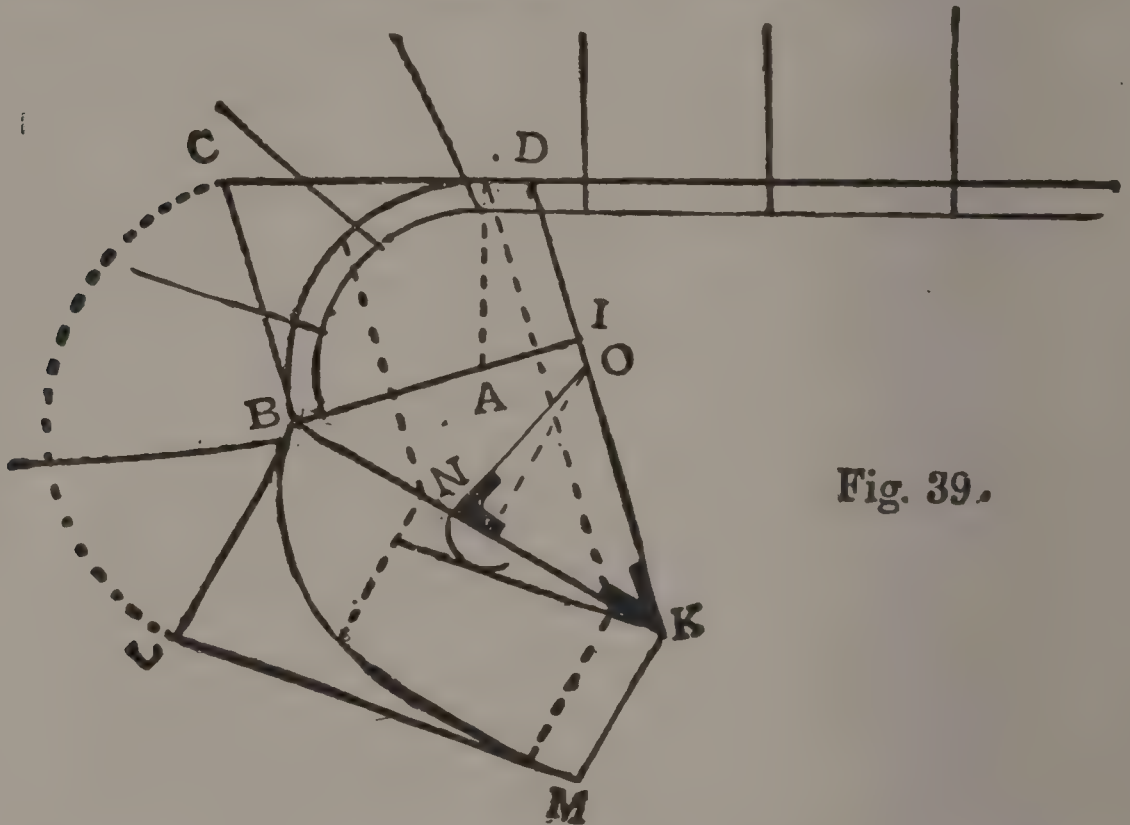


Fig. 39.

construct Fig. 39 draw radius from center A to joint of rail at newel B. At right angles to AB draw BC. This will give the angle of tangents on ground plan. In wreaths of this shape the tangent BC is always level so as to give a plumb joint at the newel.

Before proceeding further with Fig. 39 the height must be obtained by drawing Fig. 40; this is done in the manner explained in previous examples, viz., by setting up each riser and obtaining the width of the treads from the tangents BCD, where the risers cut through. To develop the mould, Fig. 39, extend BA

to I at right angles to BI, and from joint D draw DK. Make IK equal to Fig. 40. Connect BK at right angles to KB and draw BL and KM. BL should equal BC, as shown by the arc, and KM should equal ID. Connect LM and the angle is formed for the mould. The dotted ordinates give the springing line and a point through which to bend the strips to obtain the curve. The bevel for lower joint is found at K. To obtain the bevel for the upper joint draw a line from K parallel to ML. At any point on line KB describe an arc touching the line drawn from K. Draw a line from center of arc at right angles to KB, and cutting KD at O. Connect ON and the bevel is found at N for the upper joint.

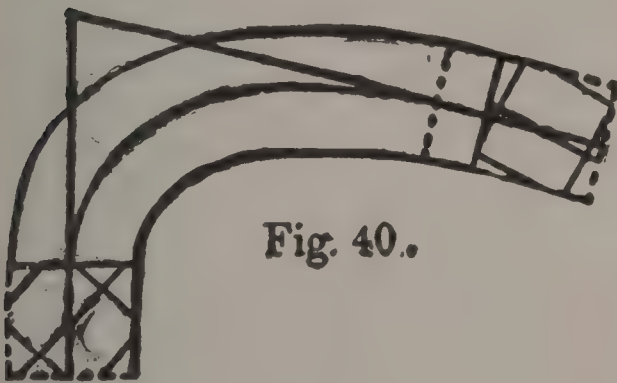


Fig. 40.

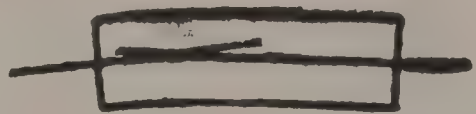


Fig. 41.

Fig. 40 shows the application of bevels, the upper bevel cuts shown through from the outside in all cases where the angle BCD, Fig. 39, forms an acute angle; when the angle is obtuse the bevel is applied from the inside, the lower bevel in all cases remains the same in application.

Fig. 41 shows the ramp.

There seems to be no difficulty presented in these problems that cannot be readily overcome if the student but applies himself diligently. We would suggest that each one of these figures be drawn and

redrawn, until the student has become so familiar with each one of them that he can draw them from memory alone. Such practice will not make very serious inroads on his time, and what investments in time are made will, in the not very distant future, return big interest.

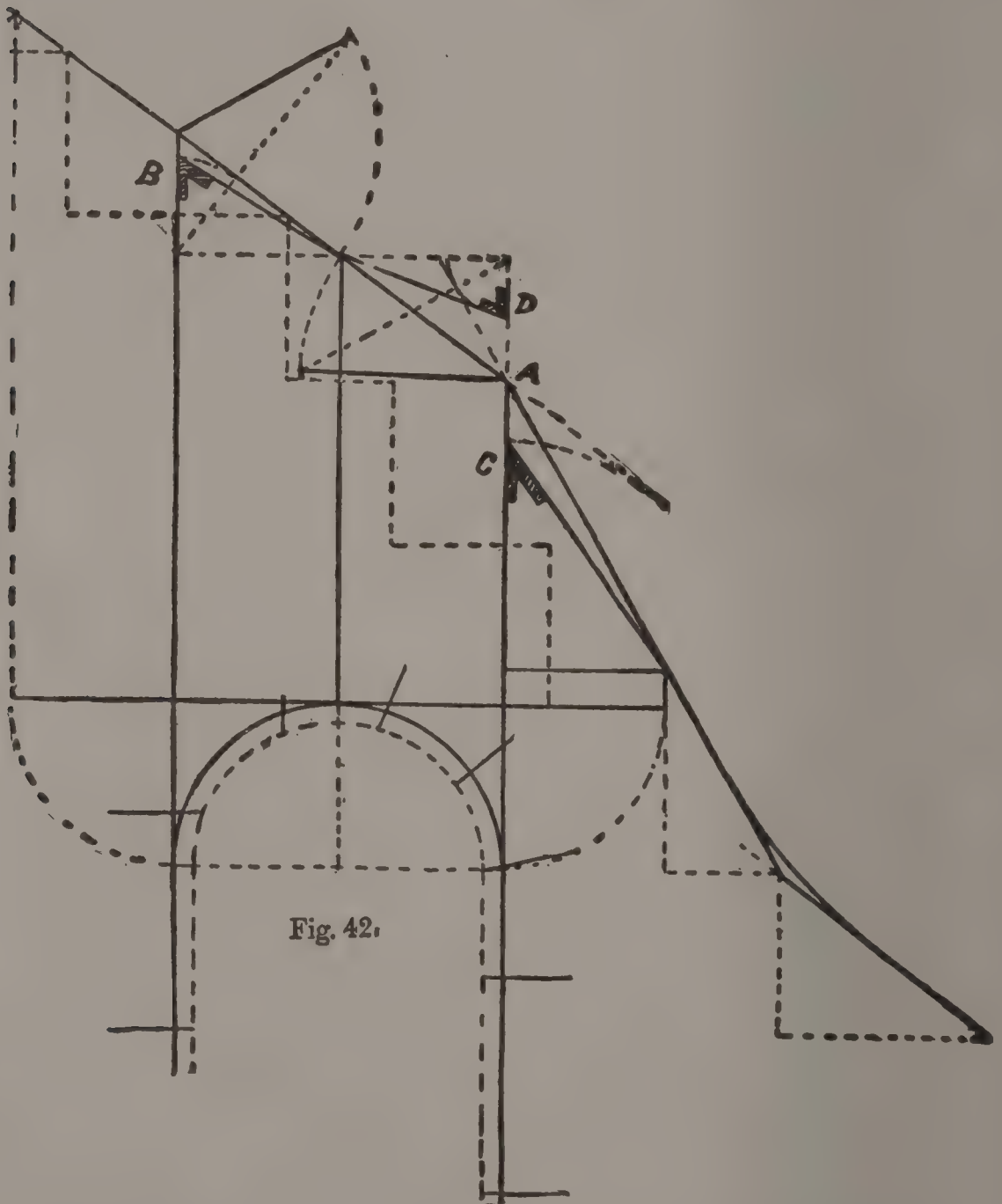


Fig. 42.

In Fig. 42 we represent a flight of stairs with four winders, quarter landing, and return flyers.

This shows the ground plans of cylinder, with risers cutting the tangent around the center line of rail; also the elevation of risers, the pitch-lines, and the development of the tangents.

It will be noticed that the upper pitch-line is the same as that of the return flyers, running down until it meets the lower pitch at A. The rail is lifted higher than usual at this point, but this is a defect which will not detract from its appearance, and makes a much better wreath than is drawn with a ramp.

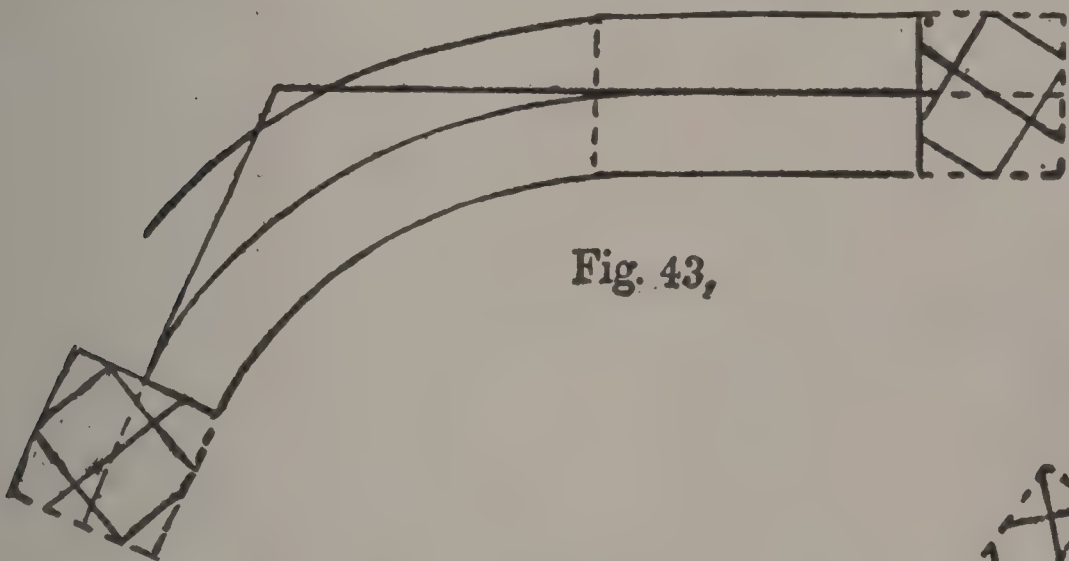


Fig. 43,

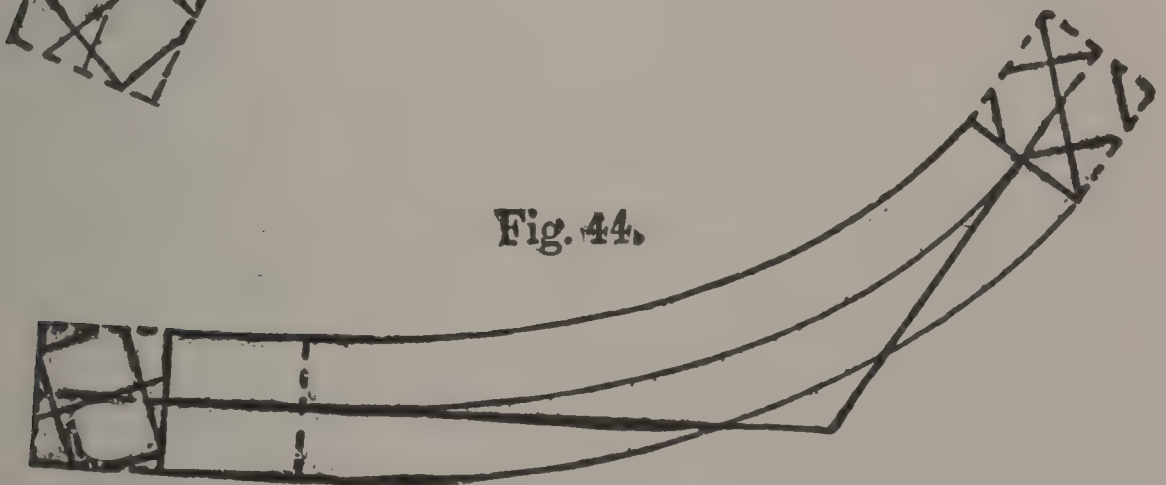


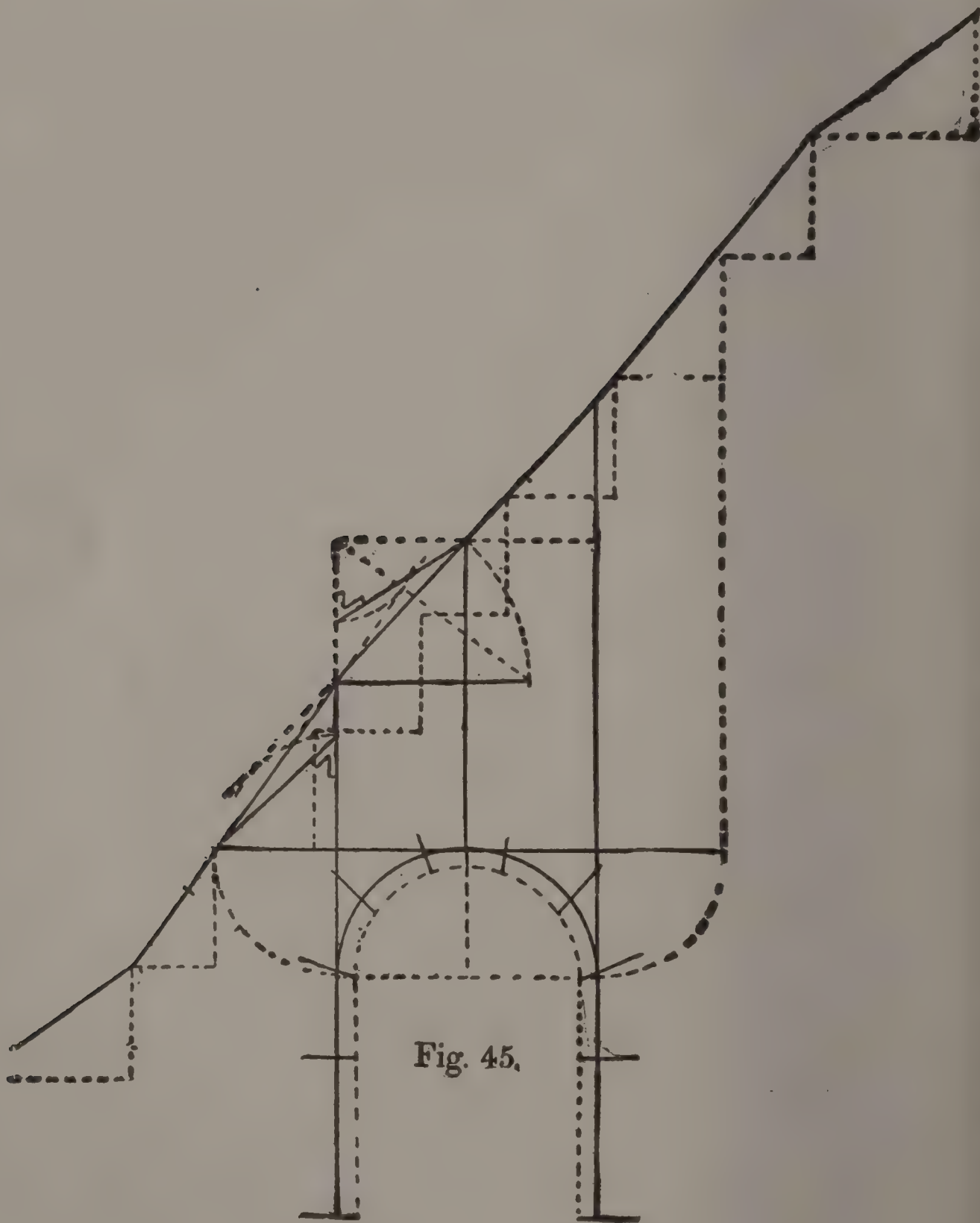
Fig. 44.

Fig. 43 shows the face mould for the lower wreath, and Fig. 44 for the upper, also sections of rail and applications of the bevels.

The bevel for upper wreath is found at B, Fig. 42, as shown in the diagram, and is the same for both joints.

The bevels for lower wreath are found at C for upper joint, and at D, Fig. 42, for the lower joint.

The plan of this stair for which the rail is intended



is shown at Fig. 9, which, upon examination, will be found to be of a type often found in our old colonial buildings.

We will now deal with a flight of stairs having seven winders forming a half circle, with flyers above and below.

Fig. 45 shows the ground plan and elevation of risers, the pitch-lines and development of tangents for face mould; the upper and lower pitch being the same, only one face mould is required. The mould is simply reversed in application, as shown in Figs. 46 and 47.

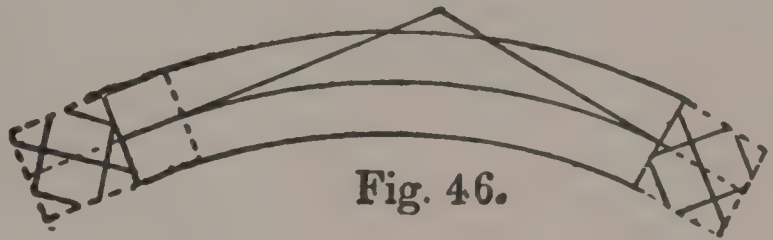


Fig. 46.

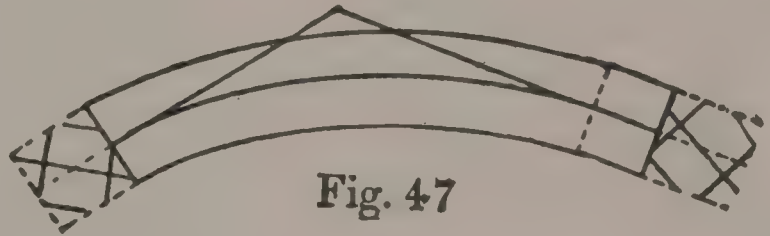


Fig. 47

Further explanations of these figures

appear unnecessary, as the lines and applications are similar to those applied in previous examples, so that a reference to previous illustrations and the descriptions and explanations attached will give a clear insight into the method of lining out the present examples.

The next examples show a method of laying down the rail for a flight of circular stairs. Fig. 48 shows the plan with cylinder and risers cutting around the center of rail and tangents. The joints are located at A, B, C and D, making four pieces; the two wreaths from A to C are alike, and only one mould is required.

The rail is in one pitch from E to A. Fig. 49 shows the elevation of steps and risers for first wreath,

and Fig. 50 the landing wreath; these are drawn in the manner as shown in previous examples, making

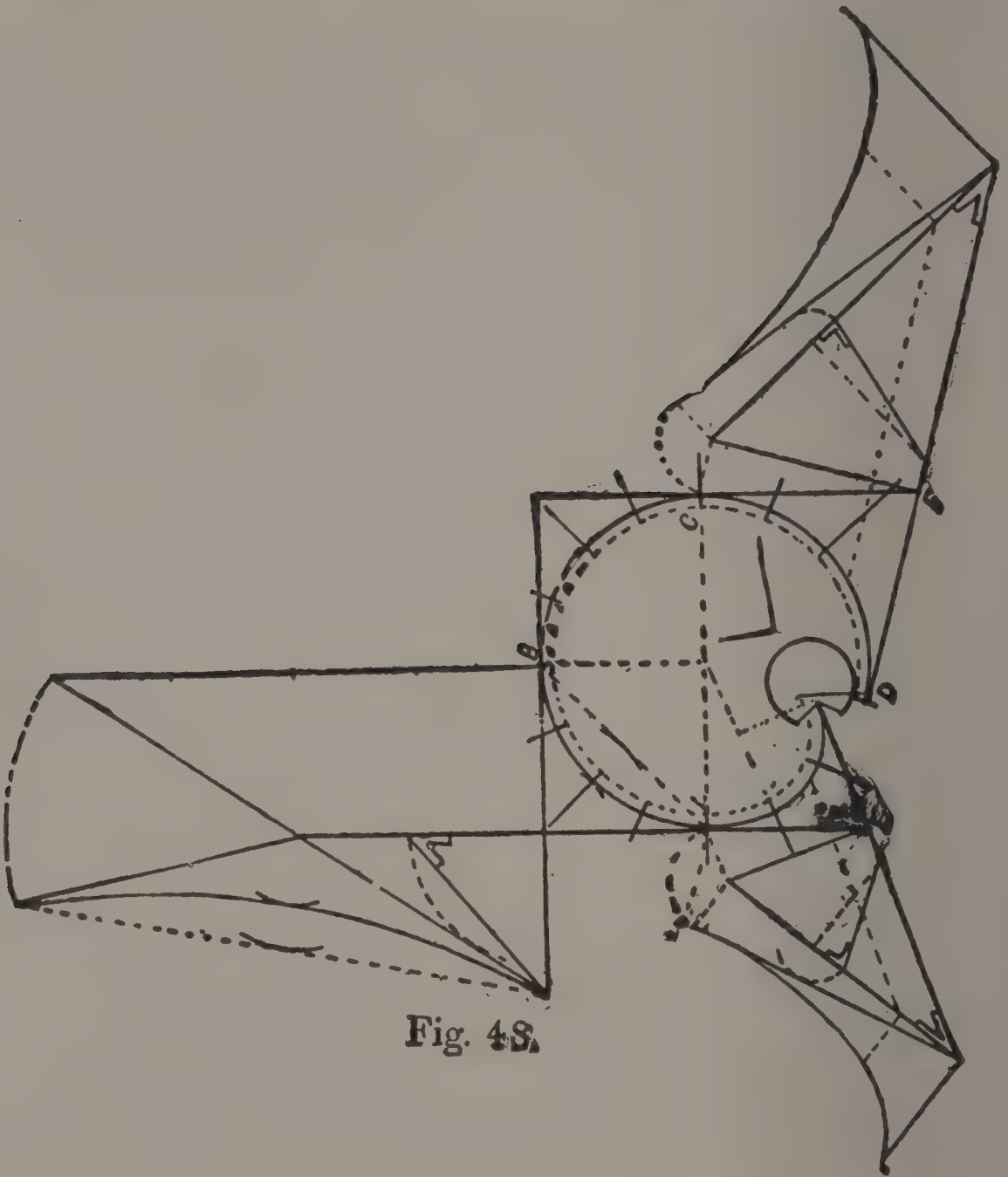
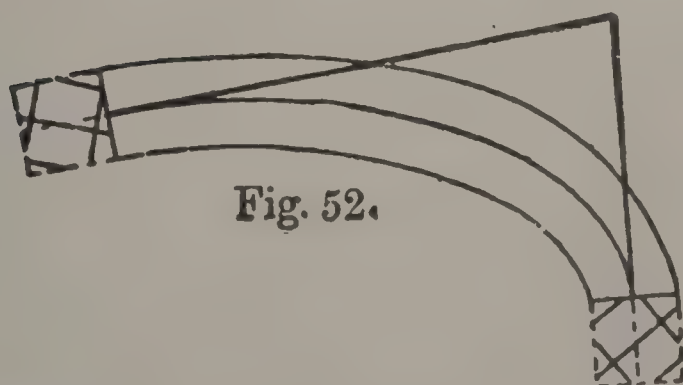
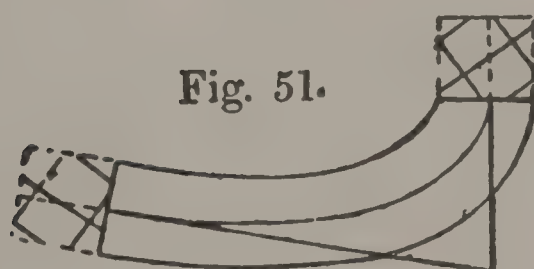
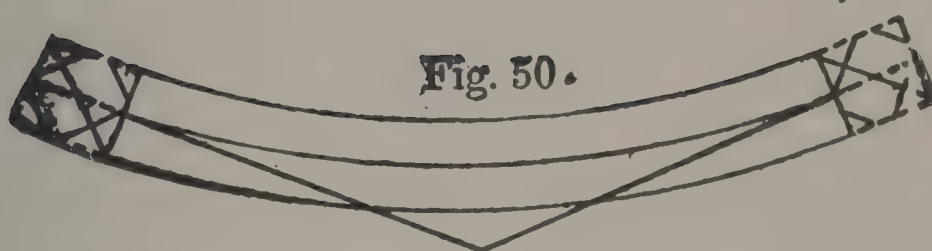
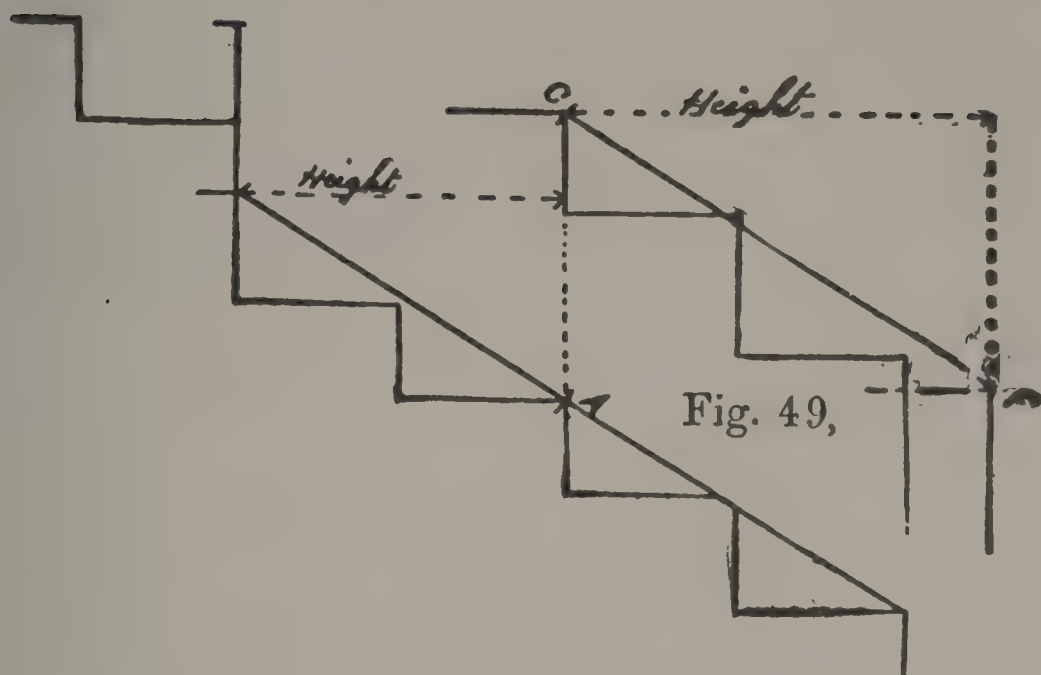


Fig. 48.

the width of treads to correspond with the points where the risers cut the tangents in Fig. 48. These elevations also give the exact height as shown; the first wreath in Fig. 49 is lifted for the newel, and the landing wreath in Fig. 48 runs half a rise above the floor.

The wreaths AB and BC simply rise from risers,



and are drawn as shown in Fig. 48. Figs. 50, 51 and 52 show the face moulds and application of the bevels, in the same manner as explained in previous illustrations.

We have now completed the treatise as **first** intended, and have shown how handrails may be laid out and made for eleven different styles of stairs, and from the rules given the student should be able to lay out a rail for almost any kind of rail he may be called upon to construct. The principles involved in this method of handrailing are well described in the earlier part of this work, and we would advise the young reader to again and again go over them, and produce the lines on a good-sized drawing board until he becomes familiar with the methods.

We have already given diagrams of the eleven kinds of stairs, and have now shown how handrails may be built over them, and it is to be hoped these efforts have not been in vain, but have been closely followed with profit to the student.

Some of the lettering in the cuts does not show up as well as would be liked, but the points referred to in the descriptions given may readily be found, particularly, if the student enlarges the diagrams to full working size—which he should do, when working out the problems.

END OF FIRST METHOD

SECOND METHOD

The method of laying out handrails shown in this section differs somewhat from the method shown in the previous section, and has some advantages the former does not possess. As this little book, however, is intended for instruction and not to advance the interest of any particular method, the editor and compiler has thought fit to present to the reader several methods—all of them of the simplest sort—in order that he may find something he can utilize in each and all of them.

Before building a handrail it is quite necessary to have the stairs, and as the “handrailer” is supposed to know how to construct the body of the stairs, we shall content ourselves with making a few remarks concerning the height of riser and width of tread.

After determining the height of the riser from the “story rod,” the right proportion of tread must be found. Sometimes steps are arranged so that it is easier for a man to go up “two at a time” than to walk up in the proper manner. The reason is both tread and riser are made small. When a riser is reduced the tread must be increased; and the contrary, when the riser is increased, the tread must be reduced in width. Joiners do not often break this rule, but masons very often do, notably in steps leading to and from railway stations. A simple rule may be given for finding a suitable proportion.

Take any suitable step as a standard step, that is to

say, if you know of a staircase which is comfortable and easy to walk up, take it as a standard to gauge others by. Suppose you have a riser given, and require the width of a suitable tread, make use of the following proportion:

As the given riser : standard riser :: standard tread : required tread :

If the tread is given and the riser required, then:

As the given tread : standard tread :: standard riser : required riser.

To work out an example, suppose 10-inch tread and 7-inch riser be taken as a suitable step. Let 6 inches be the given riser; then by substituting the value of treads and risers for the names we have, as $6'' : 7'' :: 10'' :$ the required tread. This gives $7\frac{0}{6}$ or $11\frac{2}{3}''$ for the size of a tread. Nicholson gives as a standard a tread of 12" to a riser of $5\frac{1}{2}''$. Working out the example given by this proportion we get 11 instead of $11\frac{2}{3}''$; either of these sizes will be an agreeable step.

A rough and ready rule for the usual sizes of treads and risers is to make 2 risers and 1 tread equal to 24 inches.

Before going into the working part of stair-building it must be understood that great care ought to be taken in placing the staircase in any building, and, therefore, staircases ought to be described and accounted for justly, when the plans of a building are made, and for the want of this, sometimes unpardonable errors are made—such as having a little blind staircase in a large house, and on the other hand a large and spacious staircase in a small house. In placing staircases the utmost care ought to be taken, it being a difficulty to find a place convenient for them, that will not at the same time prejudice the rest of the

building. Commonly the stairs are placed in an angle, wing, or middle of the front. In every staircase openings are required—first, the opening leading thereto; second, the window or windows that may give light to them; third, their landings. First, the opening leading to the staircase should be so placed that most of the building may be seen before coming to the stairs, and in such a manner that it may be easy for any person to find them. Second, the window must be placed in the middle of them, whereby the whole of the stairs may be lighted. Third, that the landing should be large and spacious for the convenient entering of the rooms—in a word, staircases should be spacious, light, and easy to ascend. The height of risers should be from 6 to 7 inches, the breadth of tread not less than 9 inches, and the length about 3 feet—the rule laid down for the height and breadth of steps. Workmen are, however, not to be so strictly tied to those rules, as shown above, as not to vary in the least from them. They must endeavor to make all the steps of the same staircase of an equal height and breadth. To do this they must first consider the height of the room, and also the width or compass they have to carry up their stairs. To find the height of each step they ought first to propose the height of each step, and by that proposed height divide the whole height of the room, which done, the quotient will show the number of steps. If there is a remainder, then take the quotient for the number of steps, and by the number divide the whole height of the room, and the quotient will be the exact height of each step.

Example: Suppose the height of the room is 9 feet 3 inches, and you propose your riser to be about 6

inches; bring the height of your room into inches and divide by 6 inches. You have 18 steps and 3 inches over, therefore, take 18 for the number of steps and by it divide 3 inches. The quotient will be $6\frac{3}{18}$, or $6\frac{1}{6}$, which must be the exact height of each riser. You find the breadth of steps in a like manner.

Having determined the height and breadth of your steps you then make a pitch-board which is a triangle of unequal sides, one being equal to the breadth of step, the other equal to the height, thus giving the rake of stair.

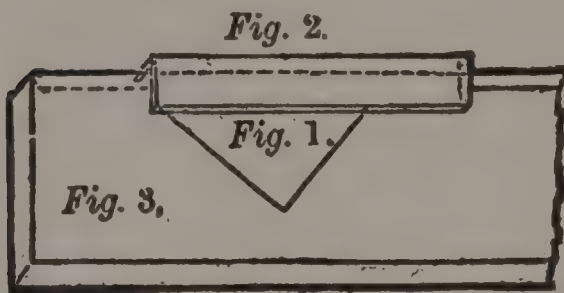


Diagram A.

Fig. 1 (diagram A) is the pitch-board. Fig. 2 is a templet about 18 inches long, $2\frac{1}{4}$ wide, which is used to form a stop or gauge for the pitch-board when you are setting up your

steps. Fig. 3 shows the templet and pitch-board applied to plank intended for the wall string.

In the formation of winding stairs much care must be exercised in laying them out. The following diagrams show a stair with six flyers and six winders, with instructions to lay out and set up the strings.

It must always be understood that you must lay down a plan of your winders, the full size the pitch-board will give the flyers. Diagram B is plan of winders. Fig. 1 is the first wall string. Set up the first three steps with your pitch-board, then set up one riser; take the width of first winder on plan and mark it on the string square with the riser; then set up another riser and take the width of your other winder up to the angle, and mark that the same way. This angle winder is called the kite winder. You must then

allow the string about $\frac{3}{4}$ of an inch longer for a tongue to go into the cross-string; then cut the string off at right angles with the step and allow about 6 inches from the step upward to form the top easing to carry

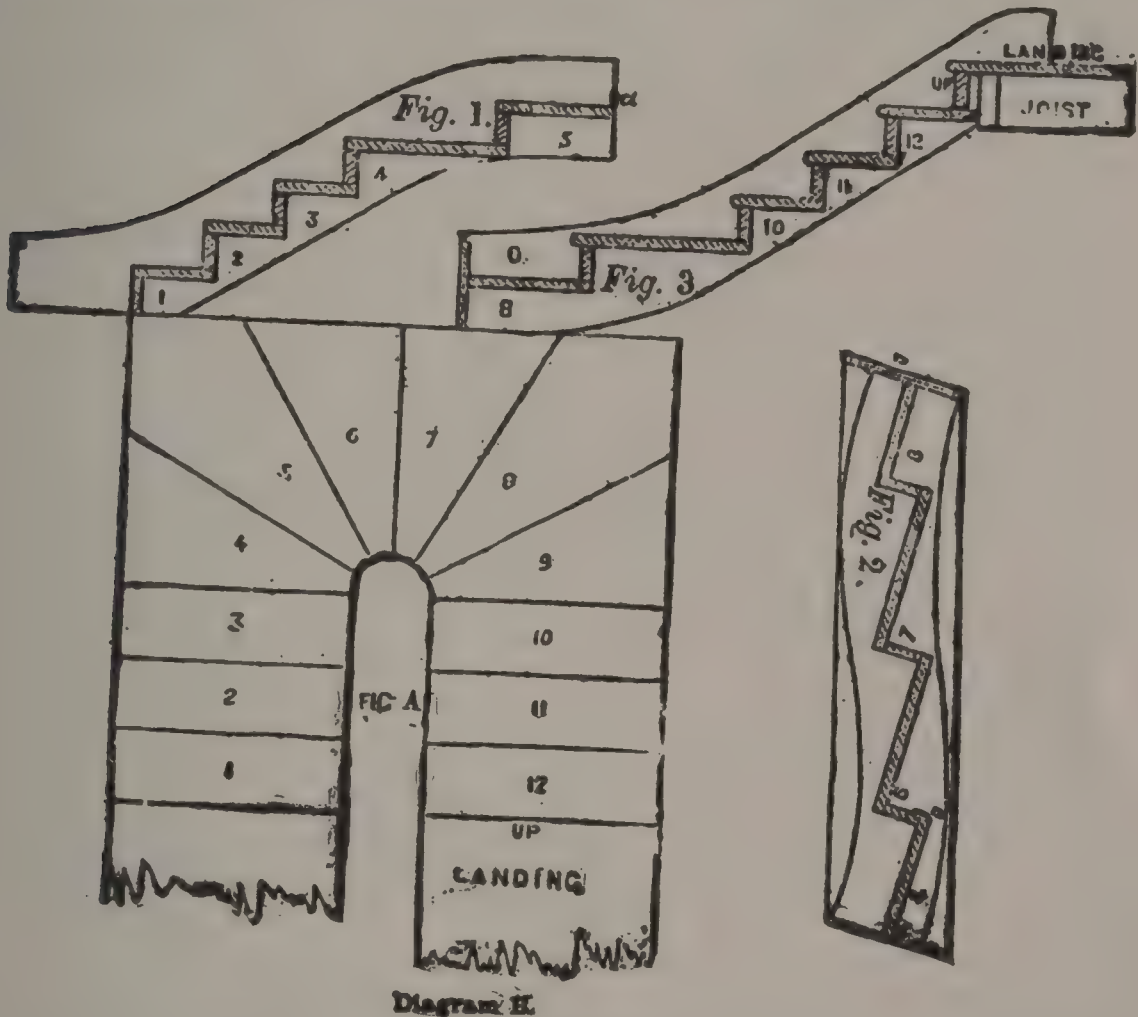


Diagram H.

out the winder. You will see that a piece must be glued on the under side of string. I have shown easing at top, and also shown ramp at bottom to receive base, etc.

Fig. 2 is the cross-string. Always glue up cross-string for stairs of this description 14 inches wide, and then make a line, AB; from that line square off the end of string. There is no particular rake for the line, it being marked at pleasure. After squaring the end from the line you must set in the thickness of the

risers and treads as shown in Fig. 1, then set in the other half of kite winder, then set up a riser square with the winder, set up the other winders and the half winder square with the end; then allow for tongue, etc. There will be enough stuff to form all easements.

Fig. 3 shows the other wall string having half a winder and a whole winder and three flyers, and risers that carry up to the landing. The string will be set out similar to the first, only the up-risers must not be forgotten. Groove the winder end of the string to receive tongue of cross-string; also glue a piece of stuff on to carry out the winder and form the easements. When setting out strings the pitch-board is the face of riser and top of tread, so allow for thickness of riser *in*, and thickness of tread *down*, and a little more for wedging as shown. C shows the tongues and grooves, F the wedging. The general depth for "housing" or grooving is half an inch. In all cases use glue up the joints.

In Fig. 1 the string is not shown finished, but this is done in Fig. 3. The strings are prepared first as in Fig. 1, and after the steps are glued up, rounded, and the cove worked on them, mortises are made for them in the string as shown at Fig. 3.

"There is nothing new under the sun," said the wise king of old—not even in handrailing, though much has been written on the subject since the celebrated Peter Nicholson pointed out the true theory of laying out this sort of work; yet, notwithstanding all the knowledge acquired since Peter Nicholson wrote, the art of handrailing has been a sealed book to nine-tenths of otherwise good joiners, and to-day it is often difficult to find a man who is not a professional hand-railer, who is willing to undertake the building of a rail over a circular staircase. This distrust, or per-

haps lack of knowledge, exists even among the best and most competent workmen, and is a great retarding factor which ought not to exist.

In order to assist those who are desirous of studying this beautiful art I will submit such problems and their solutions as I may think will be of the greatest service, and which I may be able to select from the material at my disposal.

The proper construction of stairs is an all-important part of house-building to both architects and owners, as their daily and hourly use affords comfort and ease, or tires and distresses, as the case may be, according to the accuracy with which the true principle of stair-building is observed. Strength and solidity are also important factors, especially in stairs subjected to severe usage in the passage of safes, heavy trunks and weighty packages, as in cases like that in France, where, by the falling of a stone staircase a short time ago, the lives of scores of unsuspecting people were destroyed and a large number maimed and crippled for life as a result of a defective construction and the overconfidence of a thousand human beings who risked their lives upon a thing of beauty which collapsed from overloading.

I think there are not more than three flights of stairs of similar construction to that just alluded to in the United States, the most notable and prominent of which is in the State House at Columbus, Ohio. Such stairs are supposed to be self-supporting, the wide ends of the steps being inserted in the walls of the stairway, and the cylinder ends of intermediate parts lapped and cut, locking the respective steps together, so as to provide a continuous strength to the entire construction.

The following diagram C shows a very easy way of getting out stair-rails over cylinders, 1-1-1 being the face of cylinder, 2 the center of baluster from which the tangents must be derived, and is, in fact, one of the most important points in the ground plan, for the reason that the rail is supported all around the cylinder on the top and center of the balusters.

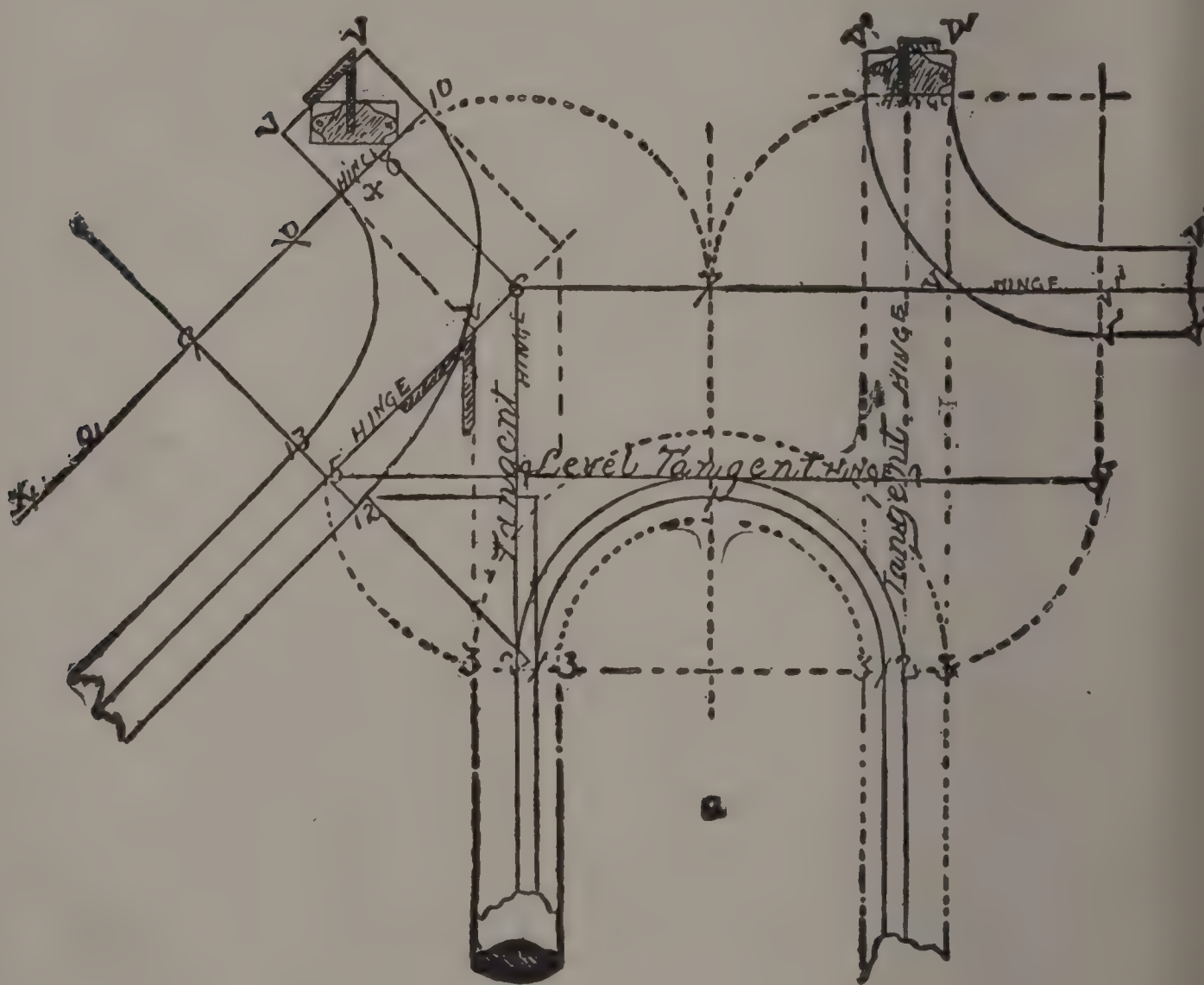


DIAGRAM C. A RAIL AROUND A CYLINDER

Commence by making the tangent as shown; place half of the rail each side of 2-3-3; draw level tangent right and left indifferently; take the compass, stand

on left, describe a curve from the spring line at 2. to cut level tangent at 5; do the same on opposite side.

The tangent being unfolded, set up the highest—say from 4 to 6 on the left; connect 6 and 5, which will give the tangent in the pitch; square out from 6 to 8, and stand compass in 6; open to 7, the center of cylinder; draw curve, cutting at 8; continue line 8 to 9, parallel with pitch 6-5; 8-9 then becomes the place of the elliptic curve covering the pitch. The breadth of rail in pitch is next to be found, as shown by the illustration, carried up from 3-8, cutting pitch-line.

Now to find the pin points to draw the elliptic curve, take the semi of the major axis (or half the length) from 9 to 10, place the compass in 12, and cut the major axis at XX,—XX being pin points for the outside curves.

Take the distance 9-11 in compass and stand in 13 and cut 0-0 on the major axis, which are the points to draw the inside curves by. The bevels are shown and how applied on the face of the moulds.

The cutting and standing up is explained as follows: Cut on line from 4 to 5 on either side, and from 5 to 13; from 13 to points marked V, V, V; from V to 6; from 6 to points marked V', V', V', V', V', V', V'; from V' to 5; hinge on lines so marked and stand in place.

This is a very simple solution of what often confronts the young workman when building his first handrail. This, of course, is intended for a straight stair having a small well hole and landing on a level floor.

Problem.—To obtain a wreath for half-space landing: When the distance between the centers of rails is equal to, or more than, the width of a step, and

the risers placed half a step from the center of rail at the crown of well, the wreaths for this class of staircases are of the simplest kind, being beveled at one end only, as the tangent line across the back of the

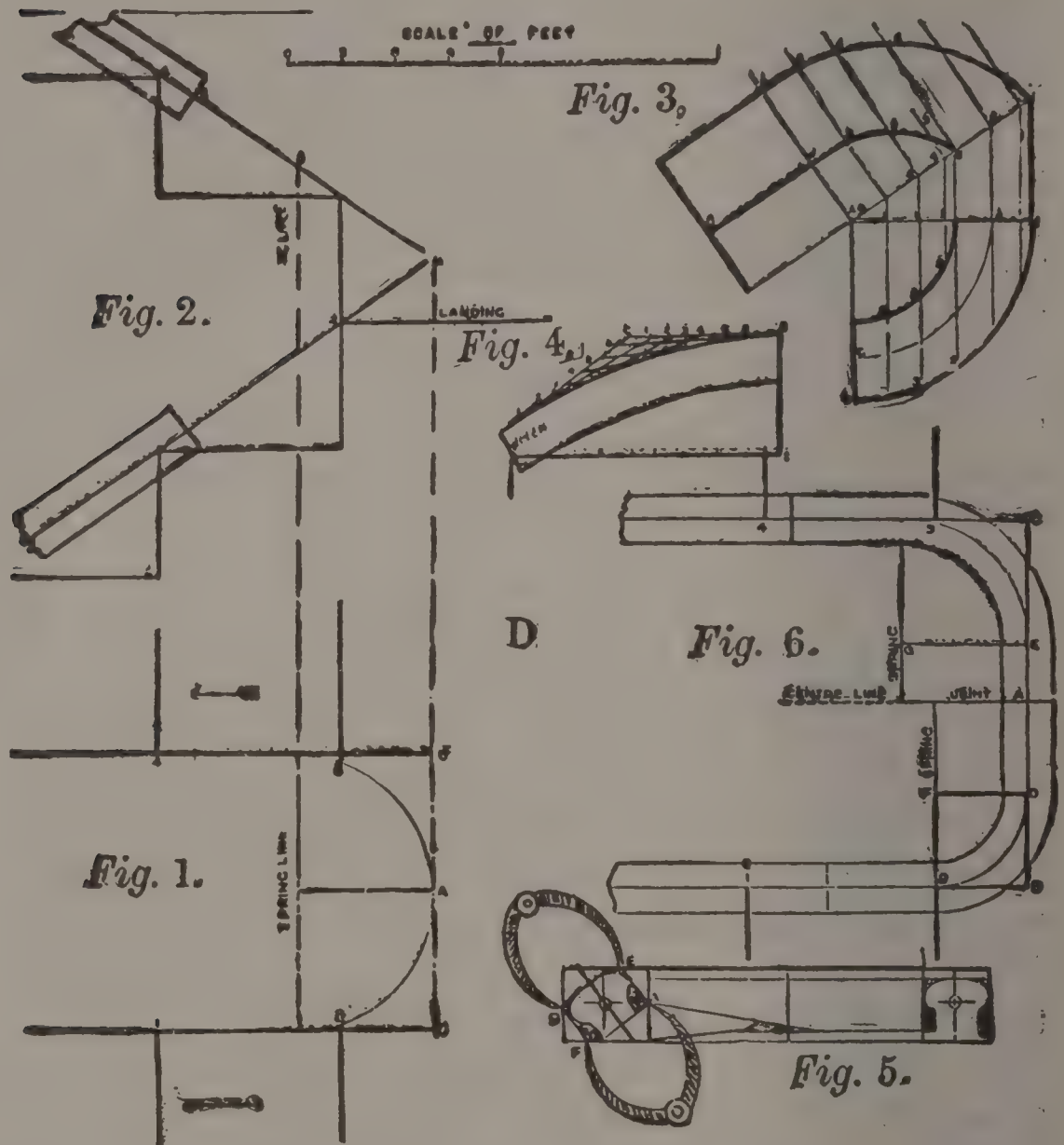


DIAGRAM D. HALF-SPACE RAILING

well is a straight level line. Fig. 1, diagram D, shows a large well with the risers 2 and 3 placed half a step from B and C; these four steps are shown in section at Fig. 2. Draw the center lines of rails 1,

2, 3 and 4, and they will meet at A, which is over A, at Fig. 1; or the risers at Fig. 1 may be in any position, so that 2B added to 3C equals the width of a step; if the distance between the center of rails is equal to a tread the risers 2 and 3 would, of course, be at the spring line. At Fig. 6 is shown a wide well with the risers 2 and 3 half a step from B and C, with the radius of center line of rail equal to half a step as 2F, or more than half a step as GE. The wreaths may be jointed at A, the face moulds for these wreaths would be drawn as at Fig. 3, and the straight length AE or AD at Fig. 6 drawn square from E and F at Fig. 3, and worked to the bevel at Fig. 5 and out of the same thickness of plank. The center of the rail on the landing would be equal to half a riser higher than the center of the rail plumb with the risers. The wreath at the start of stairs from a landing is drawn as at Fig. 3, and then turned the other side up. Fig. 3: Mark the plan of wreath and the center line, BC; draw the lines AB and AC square to each other; draw AD with the pitch-board; draw ordinates 1, 2, 3 at any distance apart parallel to AC; draw the perpendicular lines, 1, 4; draw the lines 4, 5, 6 square to AD; apply the lengths, 1, 2, 3, to 4, 5, 6, and draw the face mould through the points 5, 6; make the shank, JG, about 9 inches long parallel to AD. Fig. 4: Draw HI equal in length to outside the plan of rail, HI, at Fig. 3; make ID equal to BD, at Fig. 3; make BD and HA each half the thickness of rail square to the pitch; draw AC with the pitch-board, and draw BC parallel to HI; divide AC and CB into the same number of equal parts, and join the points 1, 1 and 2, 2, etc., which will give the top curve, and gauge the thickness of rail from the top curve.

To square the wreaths: First, cut them out square and joint the ends square. Second, center the joints, apply the bevel IFE at Fig. 3 (which is set to the top corner of the pitch-board), through the center of the top joint, and mark the square section of rail, as at Fig. 5. Third, apply the face mould on the top of the wreath and slide it up the shank until E, at Fig. 3, comes to E, at Fig. 5, and mark it; apply the mould on the under side until F, at Fig. 3, comes to F, at Fig. 5, and mark it. Fourth, set a pair of calipers to the width of the rail, and move one arm along the mark made by the face mould on the under side of wreath, and the other arm will mark, very nearly, what to take from the inside as at A, A, A, Fig. 5, and cut it out with a band saw; then gauge the outside from the inside with the calipers. Next work the top, gauge an equal portion of the top and bottom of the shank, as at Fig. 5, and lap Fig. 4, falling mould around the outside; place the shank in the bank, screw up to the right pitch and work the top level across in a direction toward the center of the well around the curve; apply a square to the top with the stock plumb on the inside. Gauge the bottom from the top. The top wreath is worked to the same hand and turned over before doweling or moulding. To joint the straight rails apply the length IG, at Fig. 3, from C and D at the spring line of well, at Fig. 2, to B and E.

Problem.—To obtain a wreath for a quarter-space landing: For small wells with the riser, A and B, less than half a step from the point C, where the space for the steps is confined for room.

Fig. 1, diagram E, shows the center line of rail and the plan of stairs.

Fig. 2: Draw the tread, DE, and riser, EA; make

ACB equal to ACB, at Fig. 1; draw the riser, BF, the tread, FG, and the riser, GH; draw DA and CM; draw HF to M; draw MJ so that the part LJ will measure 5 inches; mark the joint, K, 2 inches from L; make JI equal to JK, from I to K draw the dotted lines square to IJ and JK, and from the point where they intersect

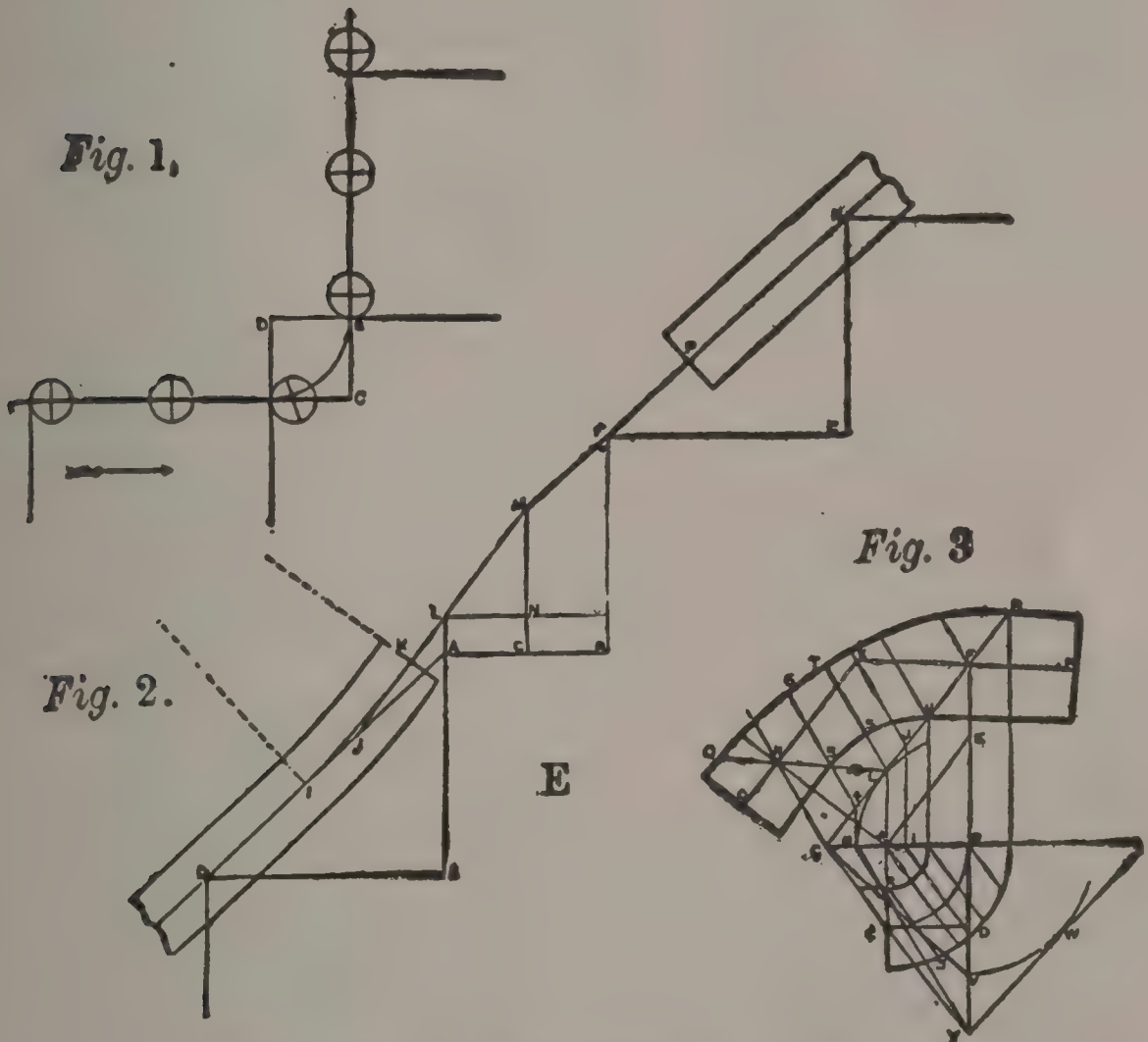


DIAGRAM E. QUARTER-SPACE RAILING

describe the easing; joint the top rail square at D about 4 inches from F; draw LNO.

Fig. 3: Mark the quadrant and the center line, BC; draw the square, ABCD; set up BE and BF equal to NM and CF, Fig. 2; draw AE, and draw FG parallel

to AE; draw AH square to AE from G. With the length, GC, cut the line at H, and draw GH.

Draw ordinates 1, 2, 3 parallel to GC; draw the perpendicular lines 1, 4, and the lines 4, 5, 6 parallel to GH; apply ID from J to K, and draw the tangents HK and KF; make HO and EP equal to LK and FP, Fig. 2; make the joints square to the tangents.

Apply the lengths, 1, 2, 3 to 4, 5, 6, and draw the face mould through the points 5, 6; draw the line 4HQ; make HQ equal H5, and from Q5U and R draw the shanks parallel to the tangents; continue GC and BD to meet at Y; from B describe the arcs LN; draw

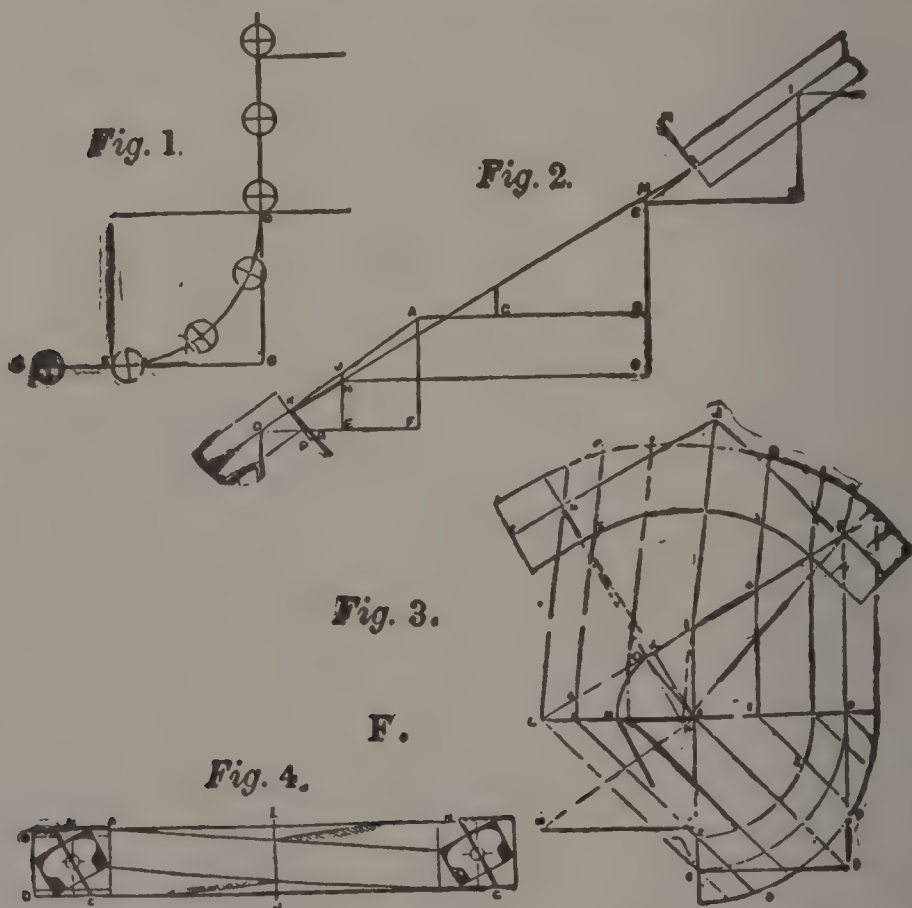


DIAGRAM F. FOR ANY SIZE CYLINDER

NY, and BNY is the bevel for the bottom end; make BM equal BF; draw MY; from B describe the arc, WV; draw VG, and BVG is the bevel for the top end.

Cut the wreath out square to the plank and a little full in the narrow part. Apply the mould and square up the wreath, taking an equal portion off the top and bottom, both inside and outside the wreath at the line ST, Fig. 3.

Fig. 1, diagram F, shows a better plan of stairs for a large well than Fig. 4, as there are *two* balusters on the landing, the same distance to the centers as those on the steps, the wall bracket and nosing are much larger, and the steps are not so confined at the well end. By this method the easing on the straight rail for small wells, where the radius of center line of rail is less than half a step (as in the last diagram), is dispensed with.

Fig. 2: Draw DEF equal to DEA, Fig. 1; draw FA, a riser; draw ABC equal to ACB, Fig. 1; draw the riser, BG, the tread, GH, and the riser, HI; draw DA and GI. Joint the straight rails square at K and L about 4 inches from J and G; draw the falling line, KL; draw EN; draw NO parallel to AB; draw KQ square to AK, and equal to half the bevel line, NC, at Fig. 4.

Fig. 3: Mark the quadrant and the center line, BC; draw the square, ABCD; set up BE equal to OM, Fig. 2; make AG equal to AC; draw EG and GC; draw AH square to GE from G. With length, GC, cut the line at H, and draw GH; draw the ordinates 1, 2, 3 parallel to GC; draw the perpendicular lines, 1, 4; and draw the lines 4, 5, 6 parallel to GH.

Apply AD from I to J, and draw the tangents, JH and JE; mark A to P, a riser, and PM, a tread; draw MA; draw AO square to MA; draw OH; continue the lines HO and JI to meet at R, and draw RE; make HF and EK equal NK or ML, Fig. 2; draw the joint

F parallel to HR, and the joint K parallel to RE; apply the lengths 1, 2, 3 to 4, 5, 6, and draw the face mould through the points 5, 6; from A describe the arc, LN; draw NC, and ANC is the bevel for both ends.

Cut the wreath out square to the plank and a little full in the narrow part; cut the joints at first square to the plank and the length, PQ, Fig. 2, longer at *both ends* than the mould; apply the bevels and the mould, and work the inside and outside of the wreath as described previously. Now cut the bottom joint to the bevel NKQ, Fig. 2, applied to the *beveled sides* of the wreath, with the bevel stock held parallel to the tangents on the wreath and apply the same.

THIRD METHOD

This method is one much used by English and German handrainers in Europe, and as it is based on the system formulated by the late Robert Riddell, it is also practiced by many handrainers in America. The system has been very much improved and simplified by Mr. John Wilson, and with the exception of a few additions and corrections it is his version of the system that is herewith reproduced, and I am sure the student will find the matter as set forth in these pages clear and easy to understand, as everything of an abstruse character has been eliminated.

The upper portion of the fence formed on the outside of the stairs is the handrail, to assist in ascent and descent of the stairs, and also for protection. It is evident that the rail should follow the line of nosings and at a height of 2' 9" to the top side of the rail from the tread at the nosing, measured perpendicularly in line with the face of the riser.

In the construction of handrails the chief difficulty is in the wreaths, where the rail is of double curvature. Simple curves in either plan or elevation will cause no difficulty.

Fig. 1 shows the plan of a rail for a level landing stairs with the risers landing and starting in the springing, the radius of the center line of rail half the width of tread.

Having the plan and center line drawn, the wreath being in two pieces and one face mould answering for

both pieces, to draw the face mould. First draw the joint line **CD**, Fig. 1, then draw the tangent lines, **AB**

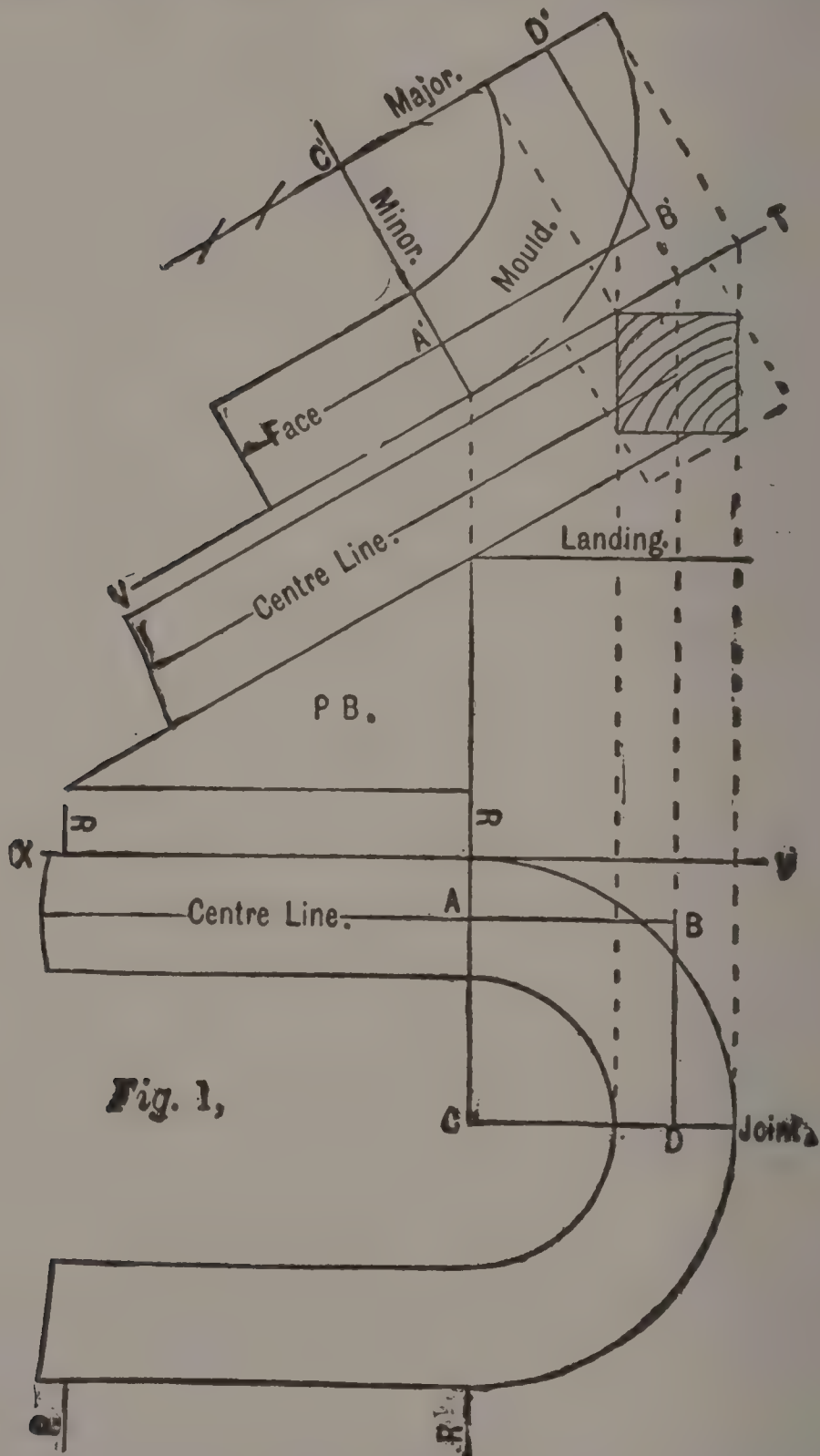


Fig. 1,

being the center line produced, and **BD** at right angles with the joint line. **AB** being equal to half the

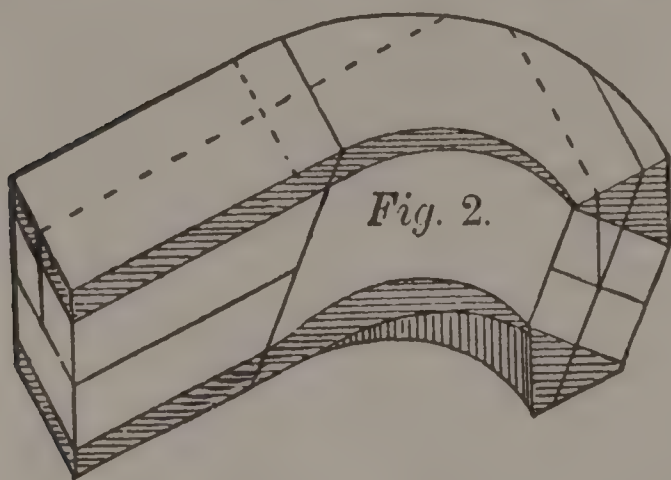
width of tread, the rail in coming up over this distance would rise the height of half a riser, causing the line BD to be horizontal; where one of the tangent lines is horizontal it is at once used as the directing ordinate. Then produce BD, and parallel with it draw lines from each side of the rail at D; and from the springing at A draw XY at right angles to BC, and place the pitch-board as shown against the riser line. Draw the under side of rail, set off half the depth of rail and draw the center line. Where it cuts the line from BD, will be the center of the section on the landing. Draw the section as shown and through the top corner draw VT. From where the lines projected from the plan cut this line. Draw lines at right angles. On each of these lines mark off the corresponding distances in plan, measuring from XY. Through the points draw A'B', C'D', and A'C', B'D'; C'D' is the major axis line, and A'C' the minor. The lines on each side of D' give the semi-major axis for the inside and outside curves for the mould, and on the minor the width of mould is the same as in the plan.

Draw the curves with trammel or string and pins. The shank may be made any convenient length.

Referring to the section at the line VT it will be seen that if the arrises of the rail were required, the dotted line through the bottom corner would give the least thickness that the rail could be got out of, and the dotted lines at right angles to VT the width at the wide end. It will be seen that if the rail has to be got out of this thickness of stuff to keep the proper height, a slab will have to come off both top and bottom sides of the shank.

Fig. 2: Having cut the wreath out square to the size of face mould, allowing extra width at the wide

end if required, the piece is planed true and the mould applied, and the tangent lines drawn on as

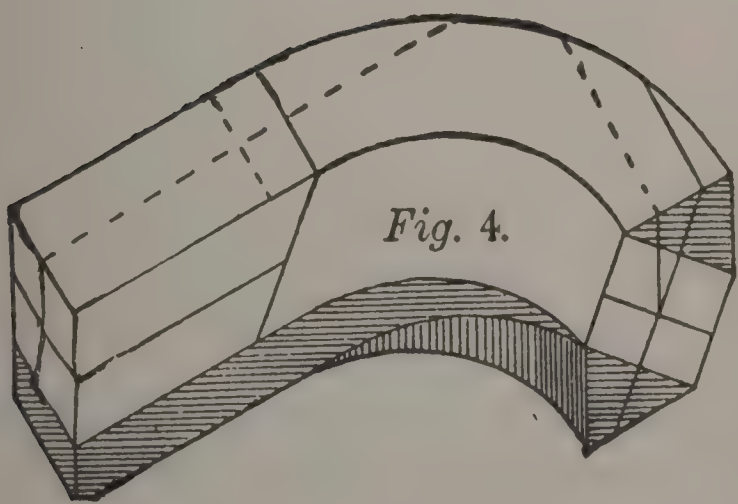
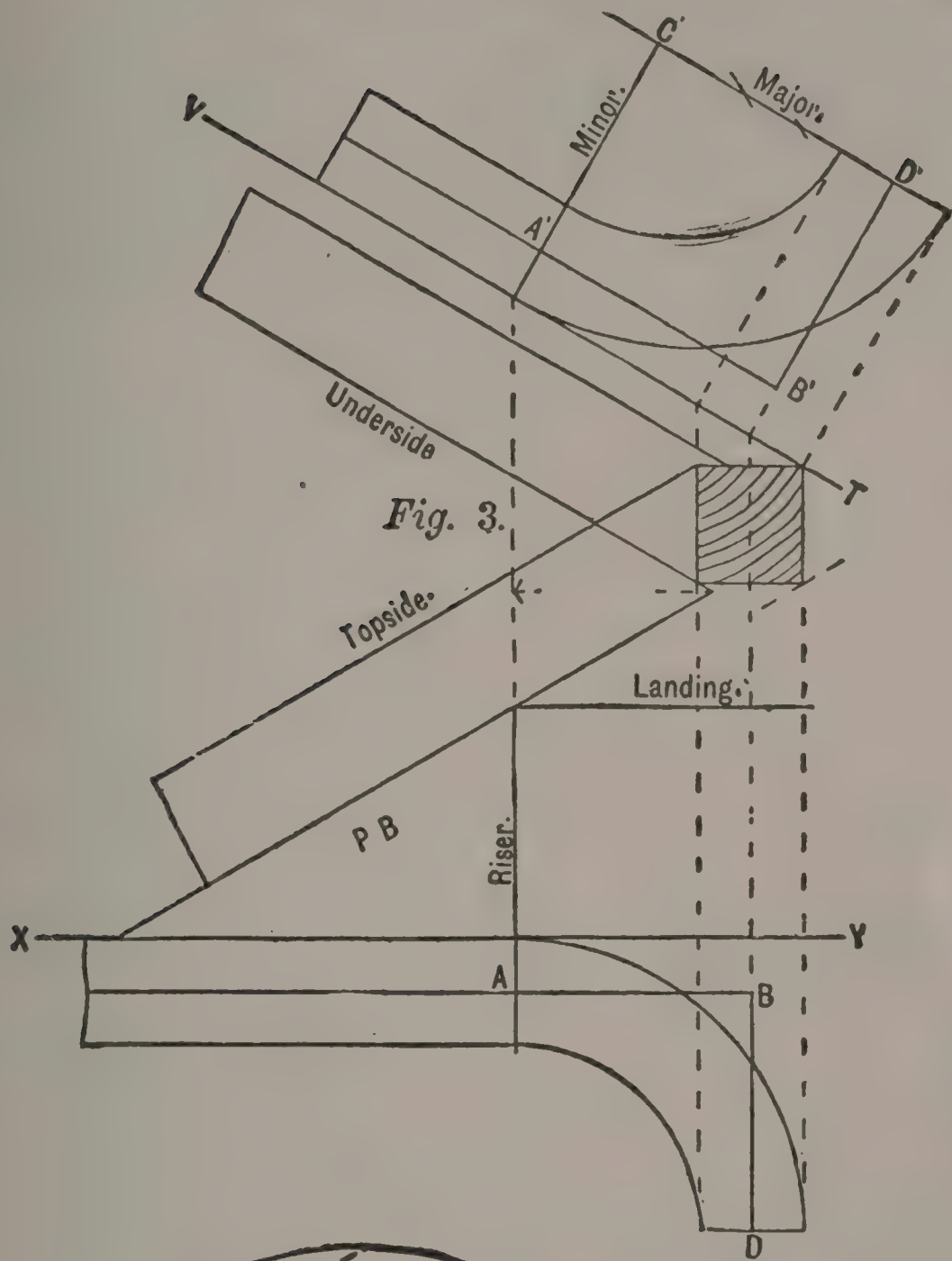


shown by the dotted lines. The joints are made square to these lines. Mark the center of the piece at each end. With a bevel set to the long edge and riser side of the pitch-board, draw the line through

the center square over a line on each face from this line as shown. This gives the new tangent lines and the distance the mould has to slide. The tangent lines on the face mould are held to these lines. Then mark for the stuff to be cut off, apply the mould on the other side and tack it on, working off the superfluous stuff to the lines and edge of the mould.

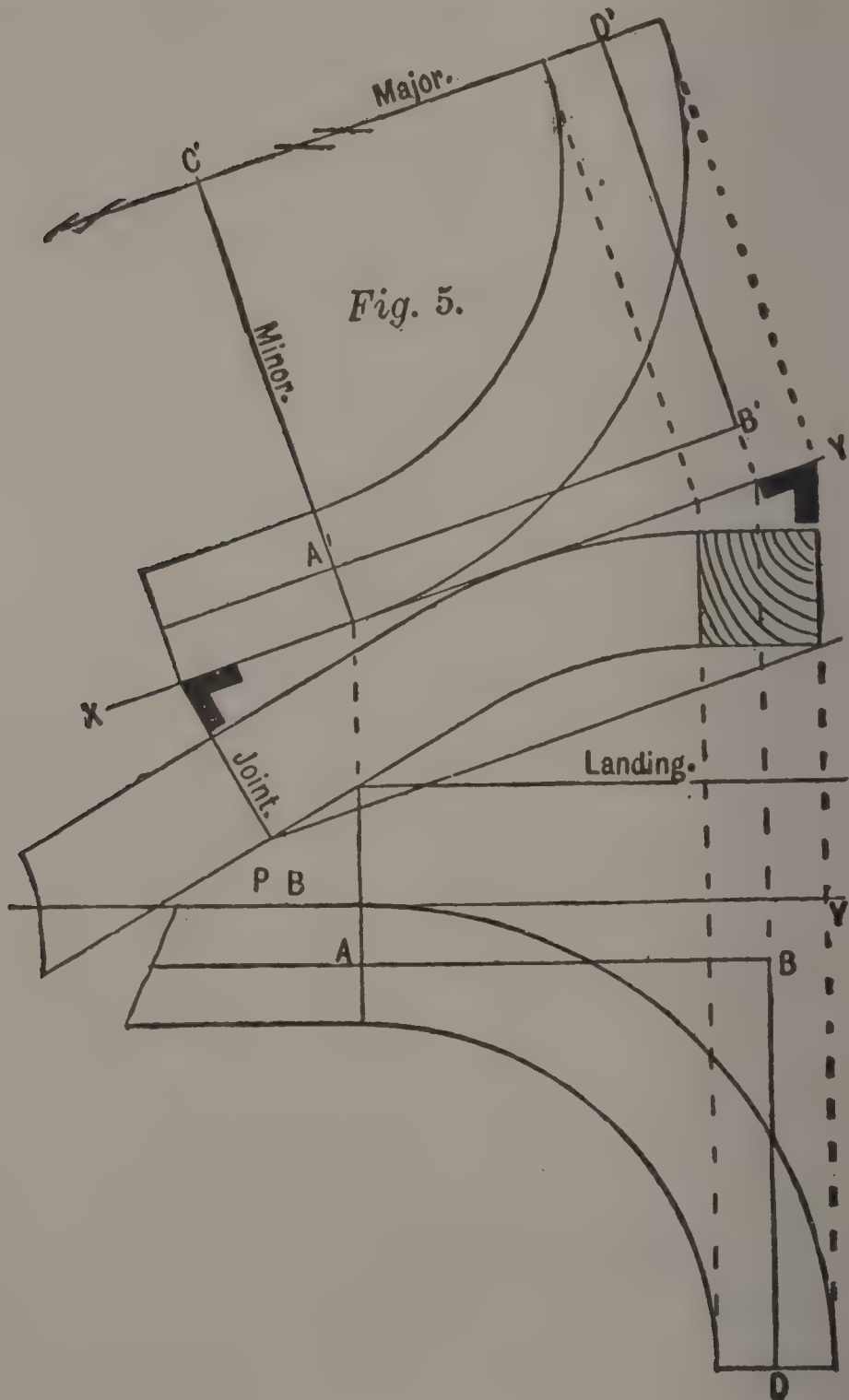
The figure represents the wreath worked into cylindrical form and ready for squaring, and the shaded portions show the slabs that have to come off. In practice this wreath is not easy to mould, owing to the rise beyond the springing on the inside.

Fig. 3 shows a better wreath. Draw the square section of the rail, and through the top corner draw the top side of rail for the lower portion, and through the bottom corner draw the under side of the top portion. Draw lines to the depth of the rail, and from the intersection of the two under sides, draw the horizontal line, and mark half the width of tread on it, measuring from the intersection. Through the point draw the perpendicular which gives the position of the risers' landing and starting; in this case they are in the



springing of the well. Project lines drawn from the springing and the section to complete the plan. The face mould is drawn the same as Fig. I.

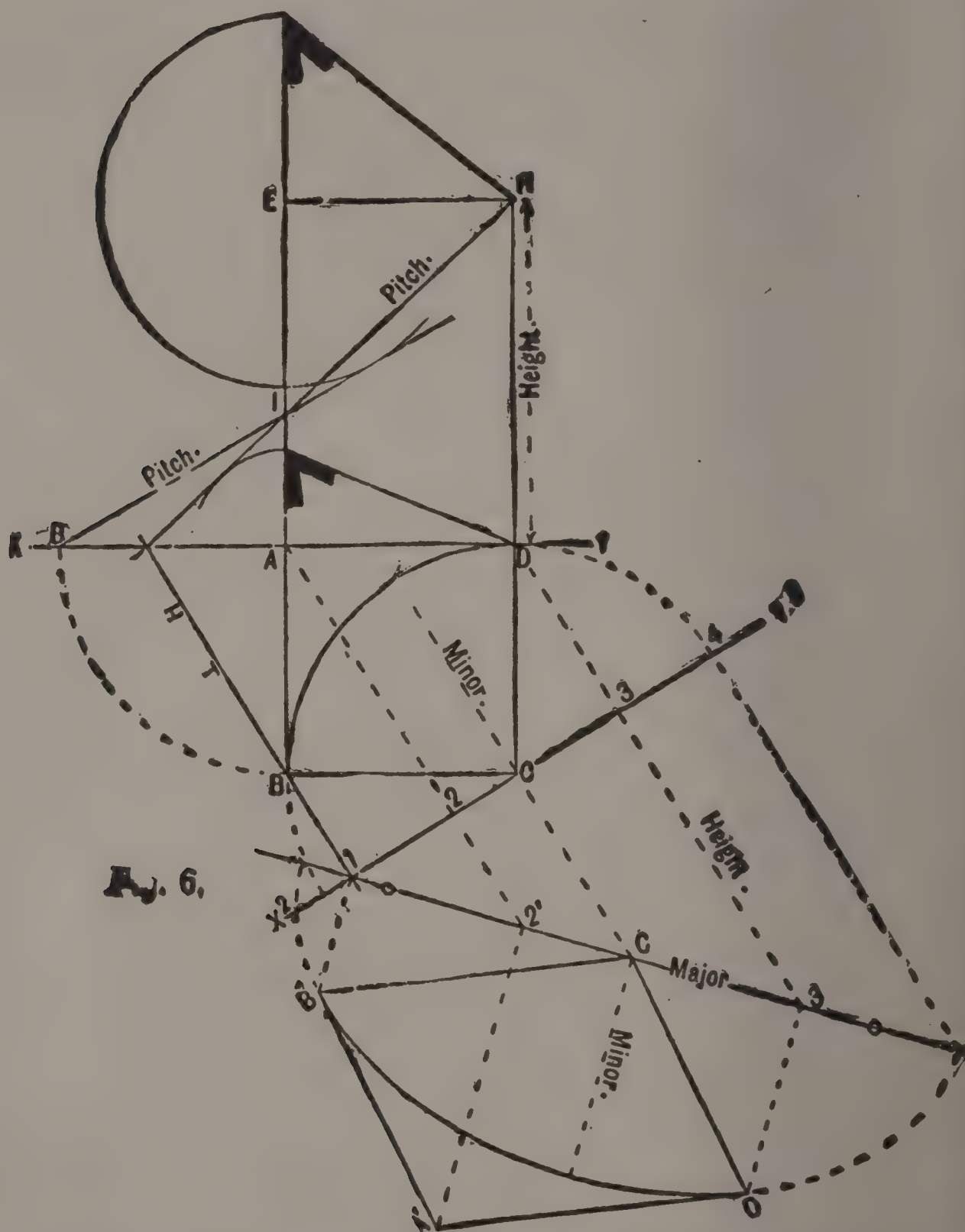
Fig. 4 shows the wreath piece cut out and worked into cylindrical form ready for squaring, the face mould being applied the same as in Fig. 2. The face mould gives the line for squaring the top off, and a better curve is obtained. It will be seen at Fig. 3 that



the shank is not in the center of the stuff. The shaded portion shows the slab to come off one side.

Fig. 5 shows the face mould for a large well with the risers in the springing. Project lines from the plan and draw the section at the proper height above the landing. Draw the line from the under side of the section to meet the under side of rail coming up. Draw the line from the joint to corner of the section. This gives the inclination of the plank, and the parallel line on the top side, the thickness; the bevel at X gives the butt joint, and the bevel at Y for sliding the mould. The face mould is drawn the same as Fig. 1.

Fig. 6: The quadrant BD is the center line of rail. AB, AD are the tangent lines, the other two the springing lines, BC and CD, which are at right angles to the tangent lines, and meeting in the center C, from where the center line of rail is drawn. Then ABCD is the plan of a square prism. Two of its faces are tangent to the center line, the other two are at right angles to the tangent faces, and their intersection is the axis of the cylinder containing the center line of rail. With the side AD as a ground line draw an elevation of that face, AD, EH. Draw the line HI as the elevation of the line AD, and the pitch at which that face of the prism is cut. With A as center, turn AB into the vertical plane; draw B'I, which is the elevation of AB, and the pitch that the face is cut by. To determine the horizontal trace of the cutting plane that contains these two lines, produce HI to meet the ground line, which is one point in HT, and B being in the horizontal plane is another point. Draw HT through these points. Having the horizontal trace HT and the plan D and elevation H of a point that the plane passes through, the inclination and section



can be readily obtained. At right angles to HT draw X2, Y2 through the center C; by doing this the line that shows the true inclination will also contain the major axis of the elliptical section. Parallel to HT

draw lines from ACD, and on the line from D set up the height 3, 3' taken from HD; then draw the line through 1, 3', which is the true inclination of the plane. From 1, 2', C', 3' draw lines at right angles to 1, 3'; then make 1B'' equal to 1B, 2'A' equal to 2A, C' minor to C major, 3'D' to 3D. Join A', B'', C', D'. This is the section of the prism, and to be correct A'B'' must equal B'1, and A'D', HI. To draw the section of the cylinder continue the center line of rail to meet X2, Y2 at 4; draw 4, 4' parallel to 3, 3'; then from C' to 4' is the semi-major axis, the semi-minor being drawn. Draw the semi-ellipse which will pass through B'' and D'.

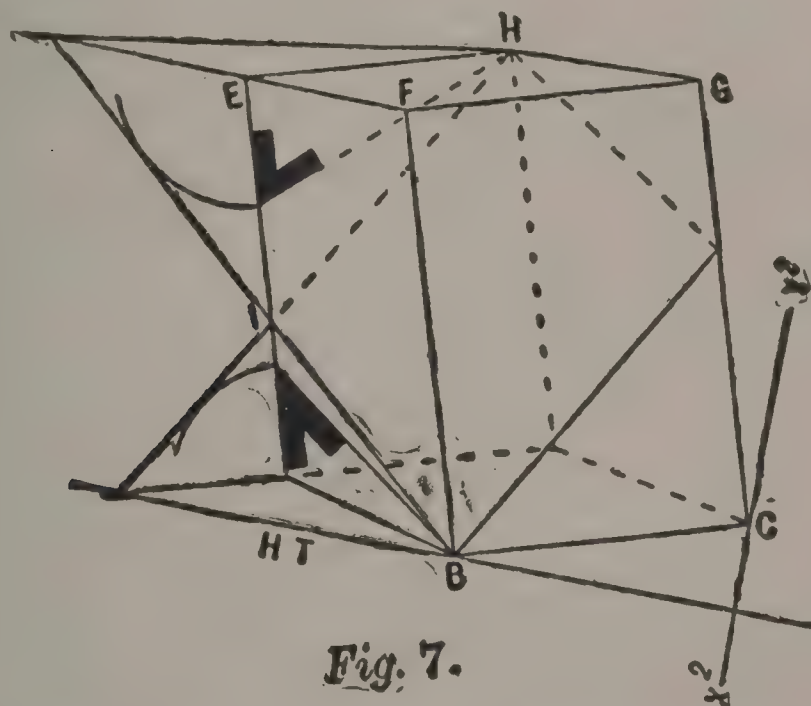
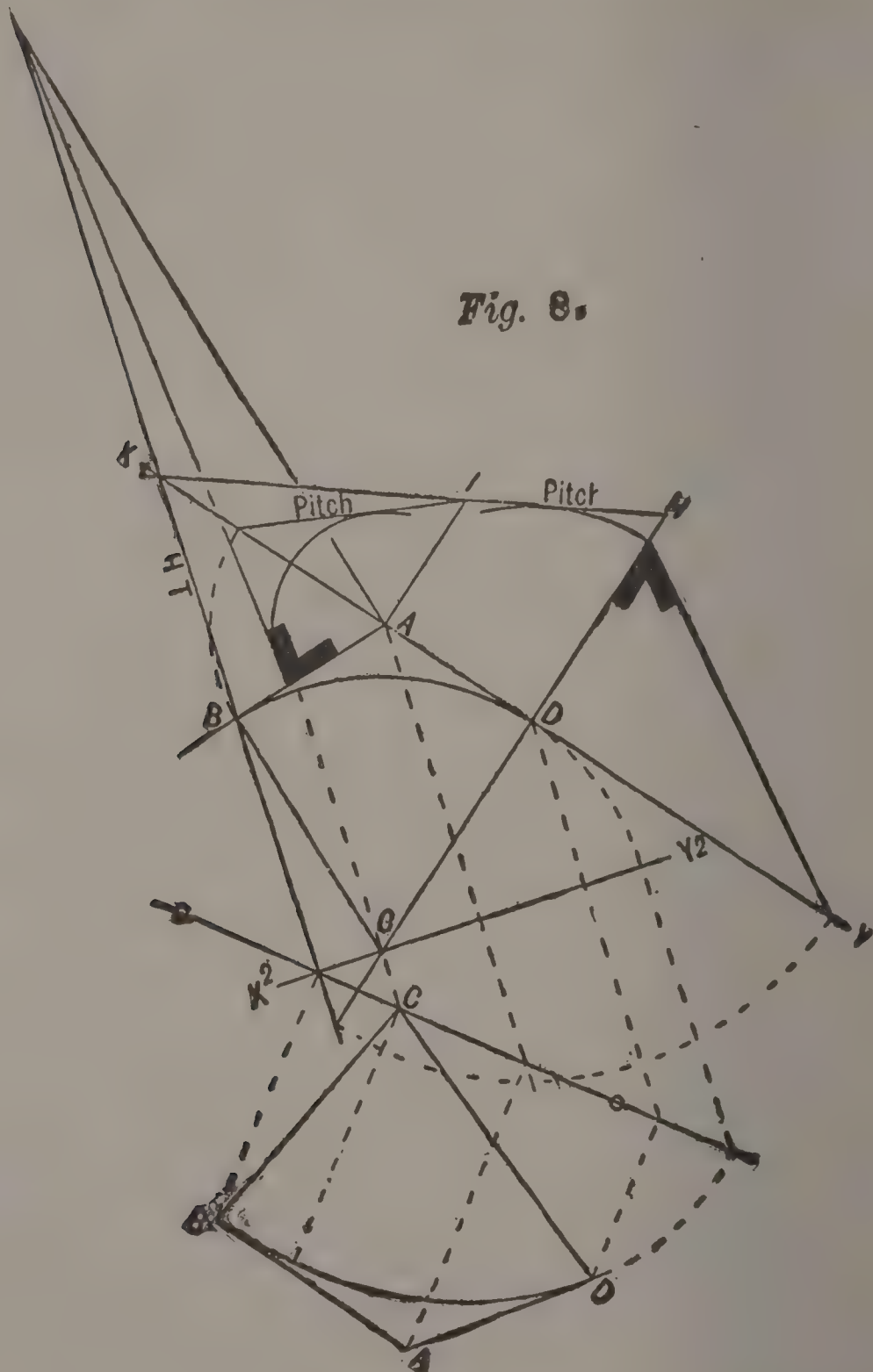


Fig. 7 is a perspective view of the prism to assist the reader to follow what is done at Fig. 1, in order to obtain the necessary bevels, that is, the angles the cutting plane makes with the vertical faces of the prism. A, B, C, D is the bottom face, and E, F, G, H the top face, and BI, HI the pitches the two faces are cut by. Produce the upper pitch to meet the ground line, AD,

produced through this point and B. Draw the horizontal trace. To find the angle between the plane and this face, with A as center draw a circle tangent to the pitch-line; and to cut the perpendicular AE, draw the

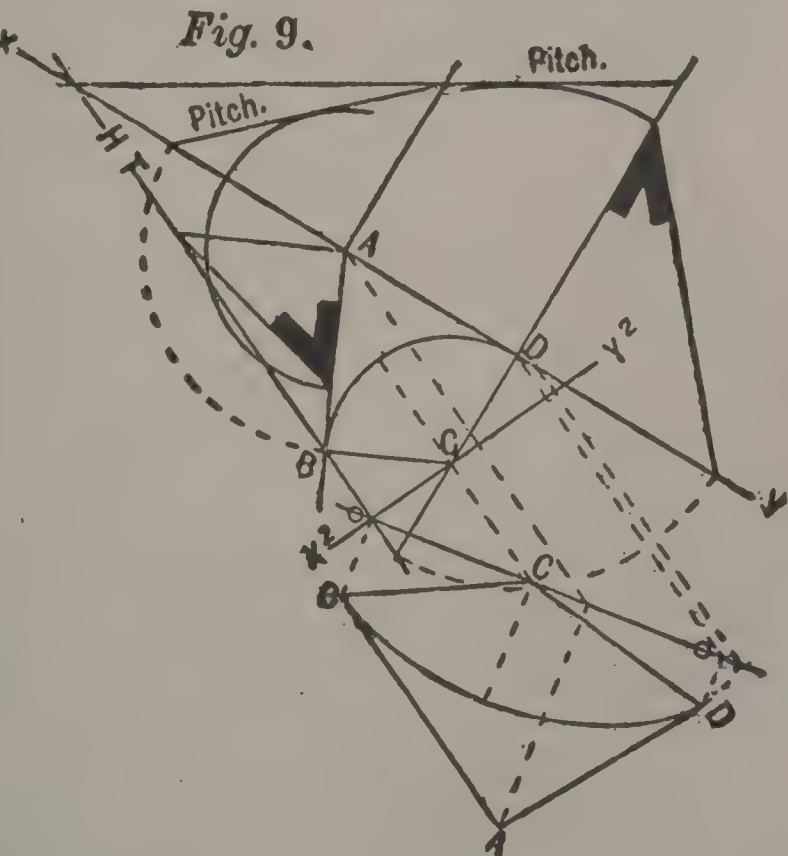
Fig. 8.



line from the intersection to B, and in the angle is seen the bevel, B and D both being the same distance from A (see D, Fig. 6). Referring again to Fig. 7 it will be seen that there is a second horizontal plane containing the top face of the prism and the pitch BI produced to meet the edge. EE produced is a point in the horizontal trace in that plane, and the dotted line through H is the horizontal trace. Then with E as center draw the circle tangent BI, and cutting the perpendicular AE, draw the line from the intersection to H, and in the angle is seen the bevel between the plane and this face. It will be seen that the bevel is found the same as at Fig. 6.

Fig. 8 shows the tangent making an obtuse angle.

Fig. 9 shows the tangent making an acute angle, the construction and lettering being the same as for Fig. 6, with the exception that both bevels are found on one horizontal plane. The bevels are found on the principle of finding the inclination of an



oblique plane to the vertical plane of projection, given in all books on solid geometry.

Fig. 10 is a sketch of the block given in plan at

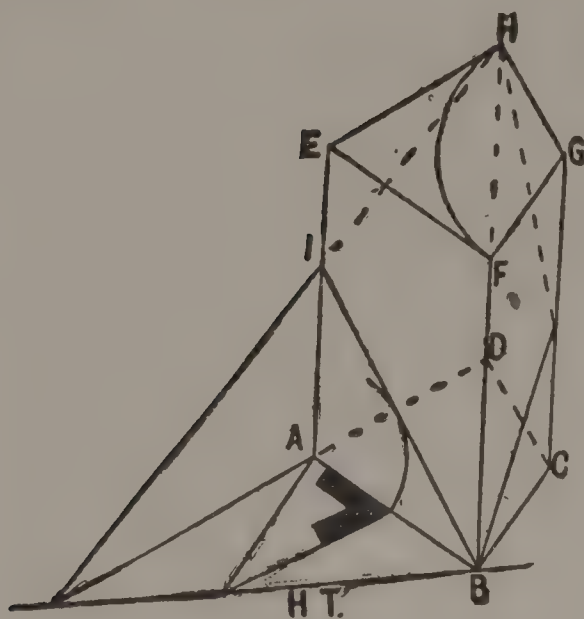


Fig. 10.

Fig. 9 to show more clearly how the bevel for the lower pitch is obtained.

Fig. 11 is the plan of a rail for a level landing, the risers landing and starting in the springing of the well. Draw the center line of rail and the joint line CD. Draw the tangent lines AB and EF, which are the center lines of the straight parts produced. The line AE is

drawn at right angles to the joint line CD, and with the springing lines BC and CF forming two squares.

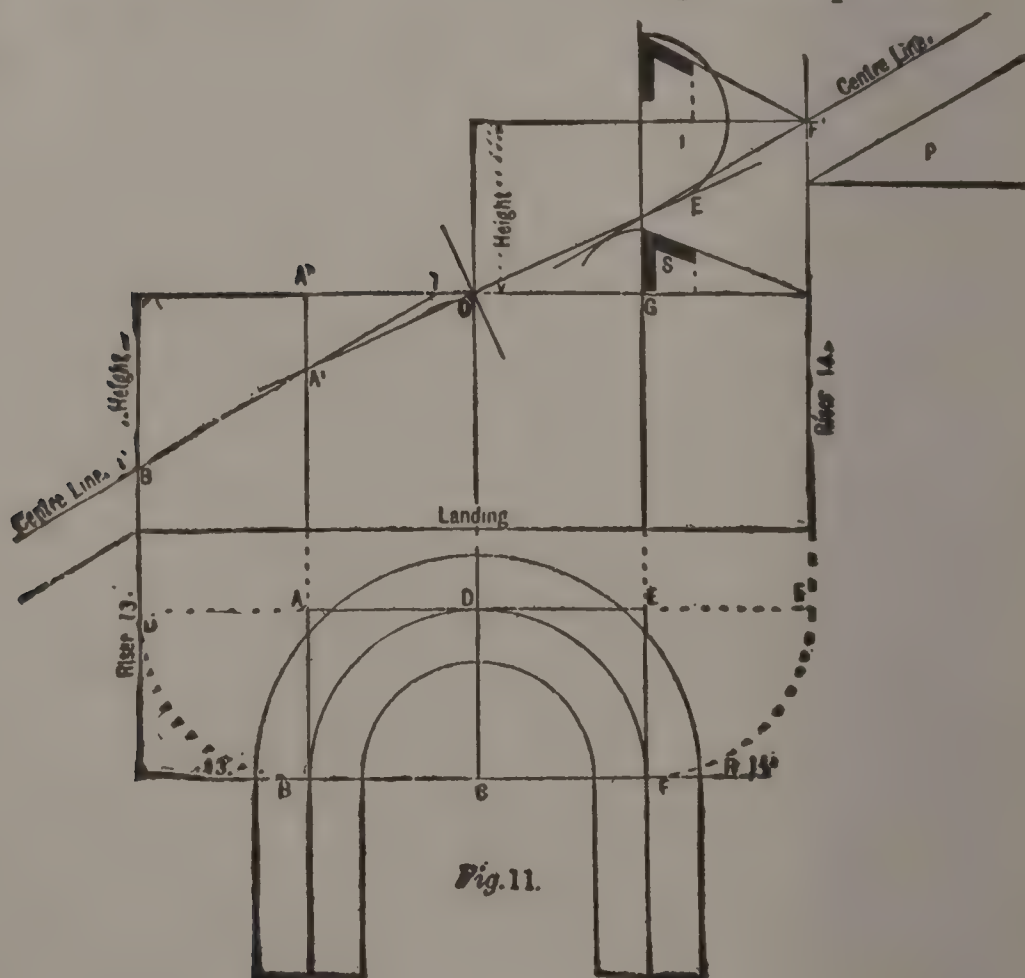


Fig. 11.

To draw the development of these tangent lines, with A as center turn AB around, and with E as center turn EF around, erect perpendiculars from B, A, D, E, F; then place the pitch-board with the risers to the perpendicular springing line at B, and draw the under side of rail from where this cuts the perpendicular. Draw the horizontal line (marked landing) where it cuts the perpendicular. From F set up the height of a riser. Place the pitch-board, P, as shown and draw the under side of rail for the top portion. Set off half the depth of rail at both top and bottom and draw the center lines. Where they cut the perpendiculars from B and F draw the horizontal lines, and through the points where they cut the perpendiculars from A and E draw the pitch across the well. Through the point where this pitch cuts the perpendicular from D draw the horizontal line. The distance between these horizontal lines gives the height the rail rises in coming up from B to D and from D to F. In this system the heights are taken from spring-line to spring-line, the shank ends are the tangent lines produced, which may be made any length.

To draw the bevels, with G as a center on the horizontal line draw the circle tangent to the center line, and to cut the perpendicular from E and from the intersection, draw the line to H, and in the angles is seen the bevel for the shank end. Then with I as center draw the circle tangent to the pitch across the well and turn it around to cut the perpendicular above I. From the intersection draw the line to F, and in the angle is seen the bevel for the center joint. Set off half the width of rail on the horizontal lines and project them up to the bevels. Measuring along the top edge

of the bevel gives half the width of face mould at the end the bevel is for.

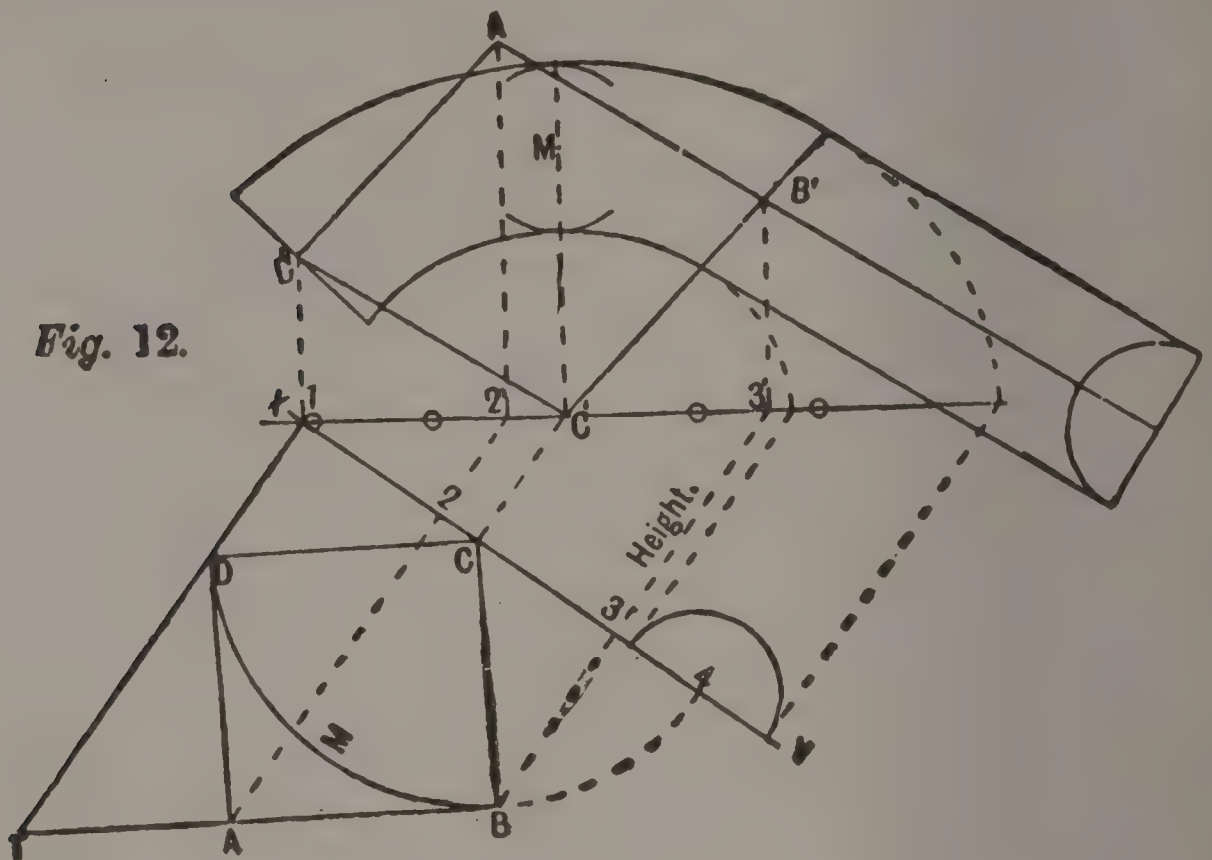


Fig. 12 is the face mould, the square, ABCD, being drawn the same as Fig. 11. Having drawn the center line the next step is to determine the horizontal trace or directing ordinate, for all ordinates must be parallel to this line.

It will be seen that the center line at Fig. 11 is drawn through the perpendicular AA' to meet the horizontal line at T ; then $A''T$ is the distance measured on AB produced, at Fig. 12, that gives the point in HT or directing ordinate, and D being in the horizontal plane is another point in the trace. Then draw HT or ordinate, and draw XY at right angles with it through the center C ; then parallel with HT draw lines from ABC . On the line from B set up the height $3-3'$ taken from Fig. 11, draw the line through $1-3'$, draw

lines from 1, 2', C', 3' at right angles to 1-3', and on these lines mark off the distances taken from the plan. Measuring from XY, 1D', 2'A'C'M'3'B', join D'A', and make the joint D' square with this line. Join A'B', and produce it to any convenient length. Make the joint square with A'B', and set off the width on each side taken from the bevel for the shank S at Fig. 1. Draw lines from D' to C' and through B'C', which is the springing line.

To draw the curve for the inside and outside of the rail, continue the center line from B to 4 in XY. Then set off half the width of the rail on each side of 4, project these to meet 1-3', as shown by the dotted lines. These two points give the semi-major axis for both curves measured from C; CM is the minor axis. Set off half the width of rail on each side of M; this gives the semi-minor axis for both curves. Draw the curves with a trammel or string and pins, which to be correct must pass through the points on the line C'B'; and the tangent lines on the face mould, B'A' and A'D', must be the same length as B'A' and A'D' in the development, Fig. 11.

In practice, as soon as the line 1-3' is drawn with all the points on it, the face mould is drawn on a thin piece of stuff with a gauge line run on at a convenient distance from the edge. This gauge line represents the line 1-3'. All the points on 1-3 are marked on the edge of the board and squared over on the face, and the distances marked from the gauge line and the face mould drawn same as Fig. 2. Then cut it out to the lines and square over on the other side the tangent, spring and minor axis lines.

Fig. 13 shows the wreath cut out square through the plank, planed true, and the mould applied, the tangent lines TT pricked off and the joints marked. The

joints are made square to these lines. Square over the lines on the ends, mark the center of the stuff on these

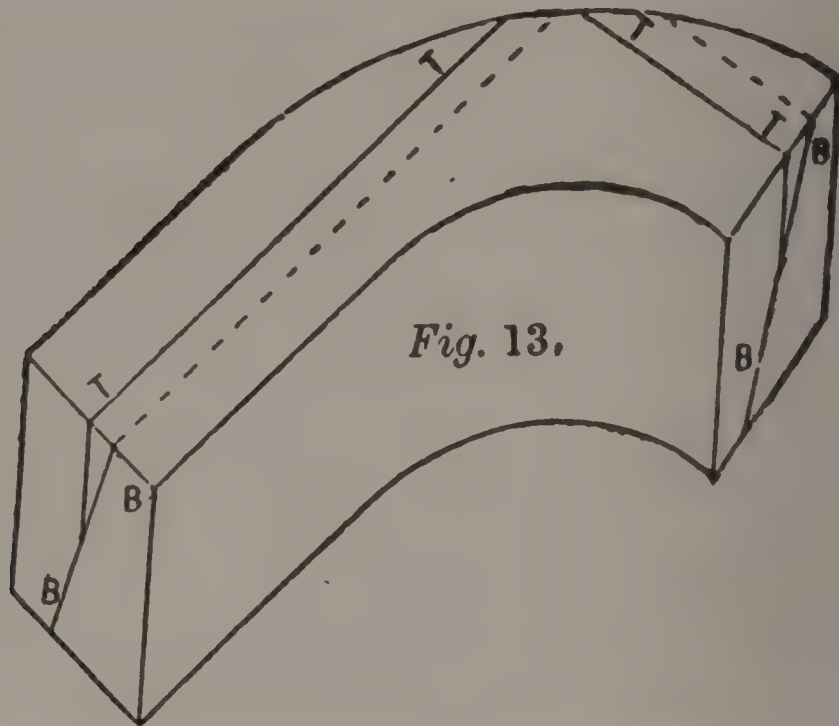


Fig. 13.

lines, then with the bevel for each end, draw the lines BB through the center of the stuff. Square over these lines on the face on both sides as seen by the dotted lines on the top side.

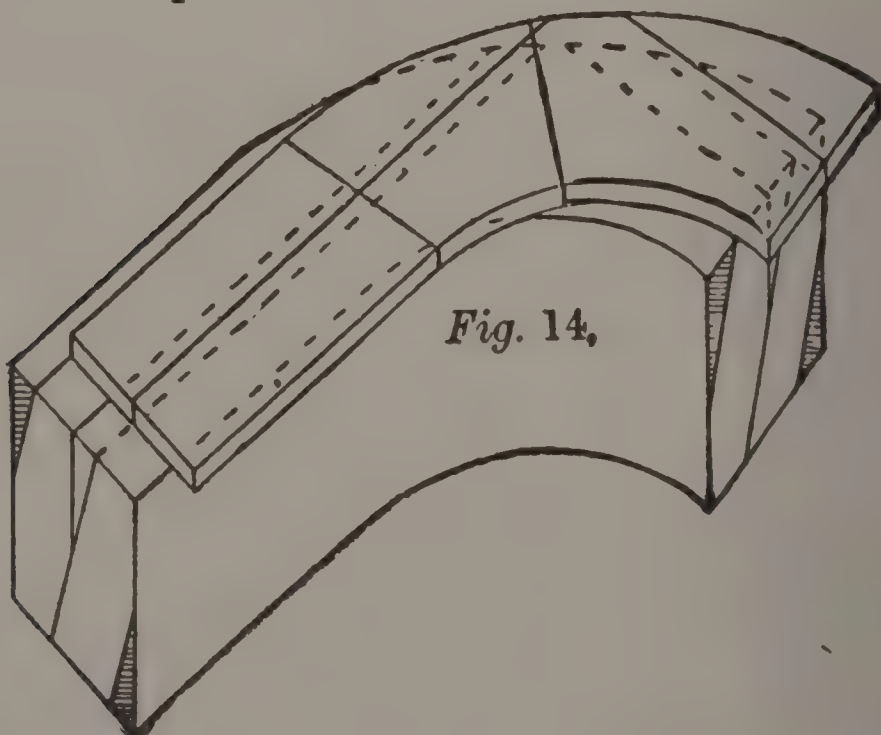


Fig. 14.

Fig. 14 shows the face mould in position with the tangent lines held to the corresponding line on the wreath. The etched part shows the amount to be taken off.

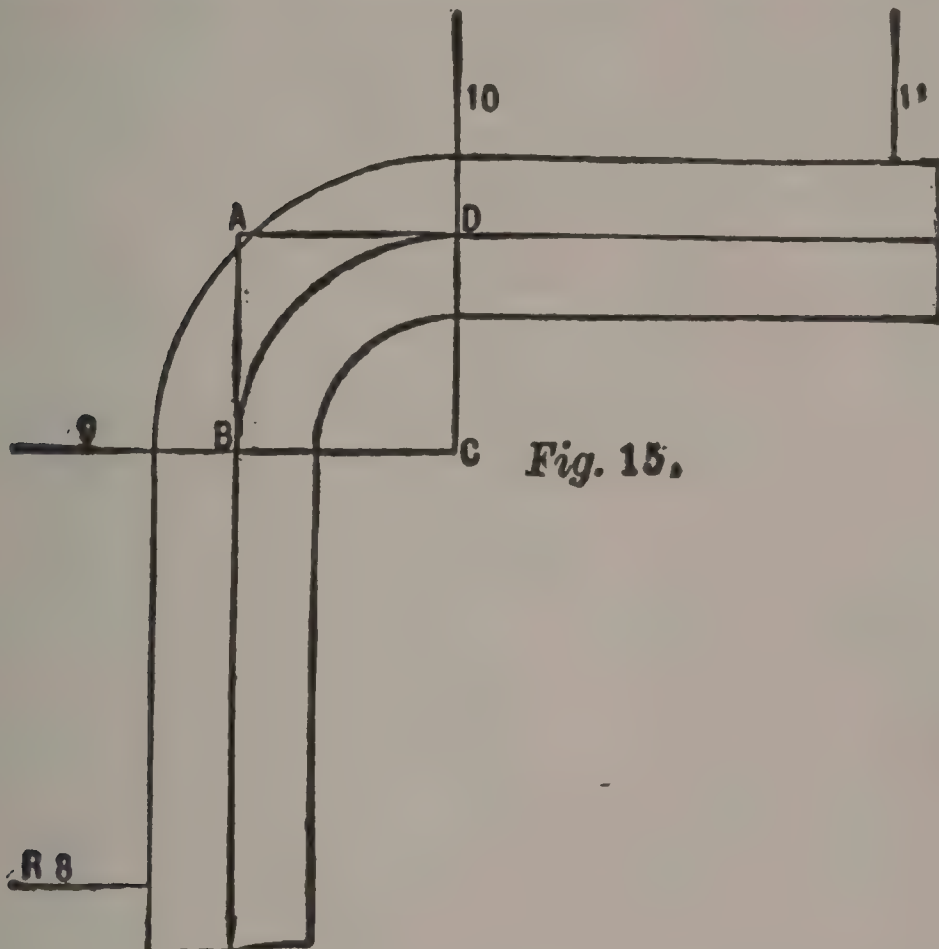
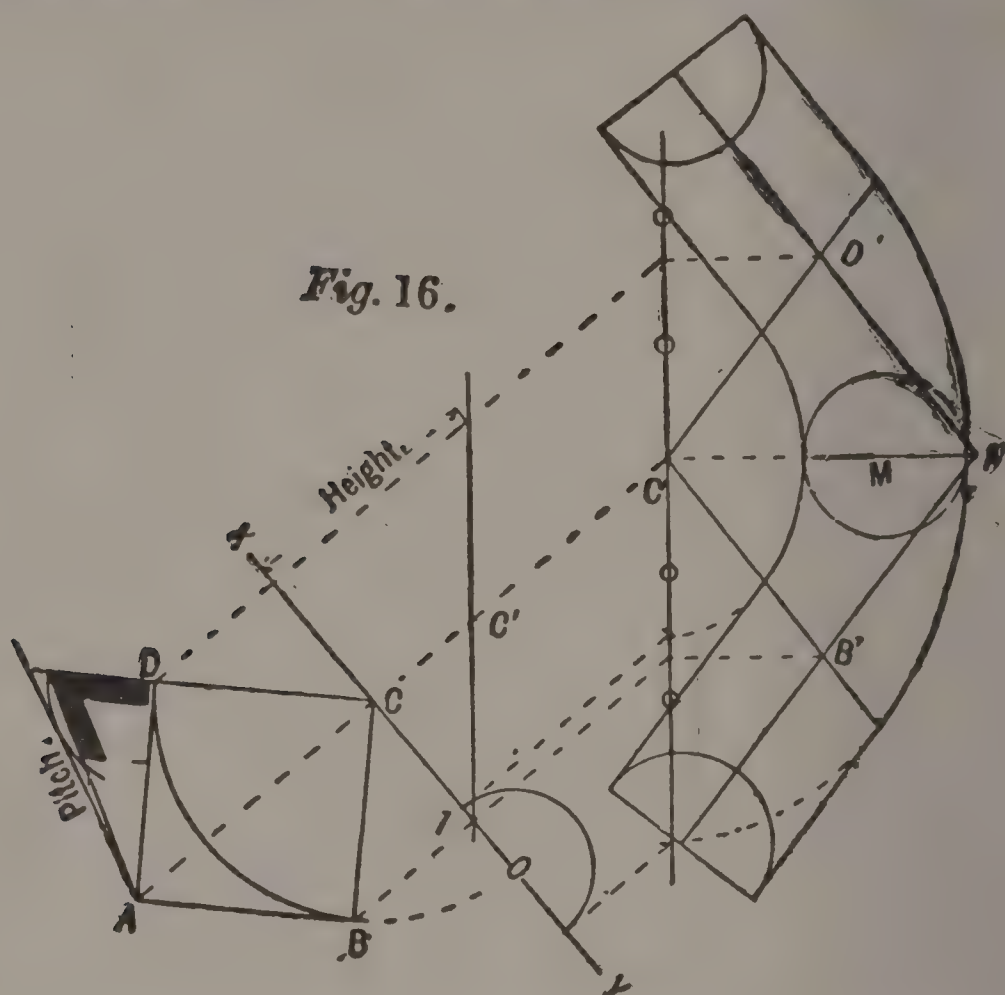


Fig. 15 is the plan of a rail for a quarter-space landing, the risers' landing and starting being placed in the springing of the well. The radius of the center line of rail being equal to half a tread, the pitch-board gives the inclination of both tangents. If a square block be cut with two of its adjacent sides to the same pitch, it will be seen that a line joining the two opposite corners is horizontal. This being known, it is unnecessary to unfold the tangents.

Fig. 16. Draw a square, ABCD, same as the square, ABCD, at Fig. 1; draw one diagonal, which is the directing ordinate; draw the line XY at right angles with

it; and draw lines D and B parallel to the ordinate. Referring to Fig. 15 it will be seen that the rail in com-



ing up from springing to springing will rise the height of one riser. Again at Fig. 16, on the line from D, set up the height of one riser. Draw the line from 1 through C; a second line is drawn parallel with the first. This line would represent the gauge line on the stuff for the face mould. Square over the lines on the stuff; from 1, C, 3', on these lines, mark off the distances taken from the plan 1B', CMA, and 3D, and through the points draw the tangent lines A'B', A'D', and B'C', C'D' the springing lines. Produce the tangent lines any convenient length and make the joint lines square with them.

To draw the bevel, place the pitch-board on the side

AD of the square with its tread side to the line, and draw the pitch through A, which is the inclination of the tangents. Then with D as center draw the circle tangent to the pitch, and cutting the side CD produced, draw the line from the intersection to A, and in the angles is seen the bevel for both ends. Set off half the width of rail on DA, project it up to the bevel. This gives on the top edge half the width of face mould at each end. Set off this width on each side of the tangent lines $A'B'$, $A'D'$, and draw parallel lines through the points to the springing lines $C'B'$, $C'D'$. To draw the curves turn the center lines around to meet XY at O; on each side of O set off half the width of rail; project these on to the line 1-3', which gives the semi-major axis for each curve. On each side of

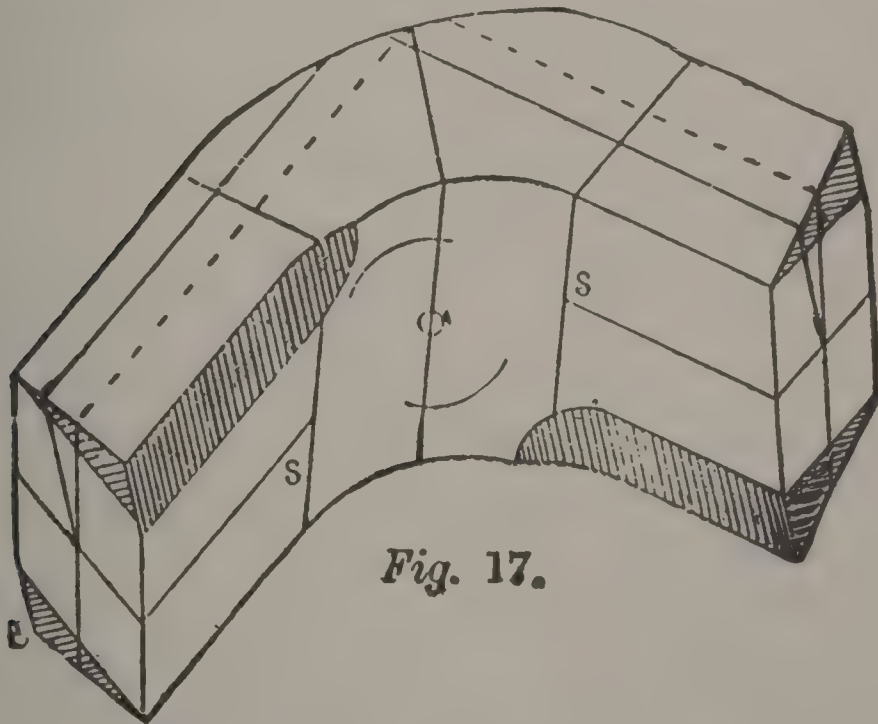


Fig. 17.

M on the minor axis line, set off half the width of rail; these give the semi-minor axis for each curve. Draw the curves which must pass through the points on the springing lines on each side of B' and D' .

Fig. 17 is the wreath worked into cylindrical form,

and the lines shown ready for squaring. To draw the lines on the stuff, a thin piece is made to the size of the rail before being moulded, and a gauge line run through the center both ways. The one through the depth is held to the line drawn across the end or joint with the bevel, and the other kept to the center of the stuff. Mark the top and bottom, which gives the shaded portions to come off. The line through the center is squared over on each side as far as the springing lines at SS, the minor axis line is drawn across the stuff parallel with the springing lines. Mark the center of the stuff on this line, and with O as a center, and the compasses set to half the depth of the rail, draw the two arcs as shown. The outside of the wreath is marked in the same manner.

In squaring the wreath the slabs at B and T are worked off square with the joints as far as the springing lines, then eased around tangent to the arcs of circles, the two opposite slabs being worked off parallel to the depth of the rail.

Before being squared the height must be tested. The wreath is put in the vice or bench screw, and the sides and springing lines set perpendicular to a board planed true and laid on the bench top. With one end of a rod on the board, mark the point where the center line cuts the springing line at S, then move the rod around to the other point S, still keeping the end on the board, and mark the point. If the distance between the two points on the rod equals the height at Fig. 2 the wreath can be squared, if not, the center lines must be raised or lowered to suit.

Fig. 18 is the plan and stretchout of the tangents for another quarter-space landing, the center line being struck with a smaller radius than Fig. 1. The tan-

gents are unfolded and the center line drawn at the top and bottom portions as shown. The center line

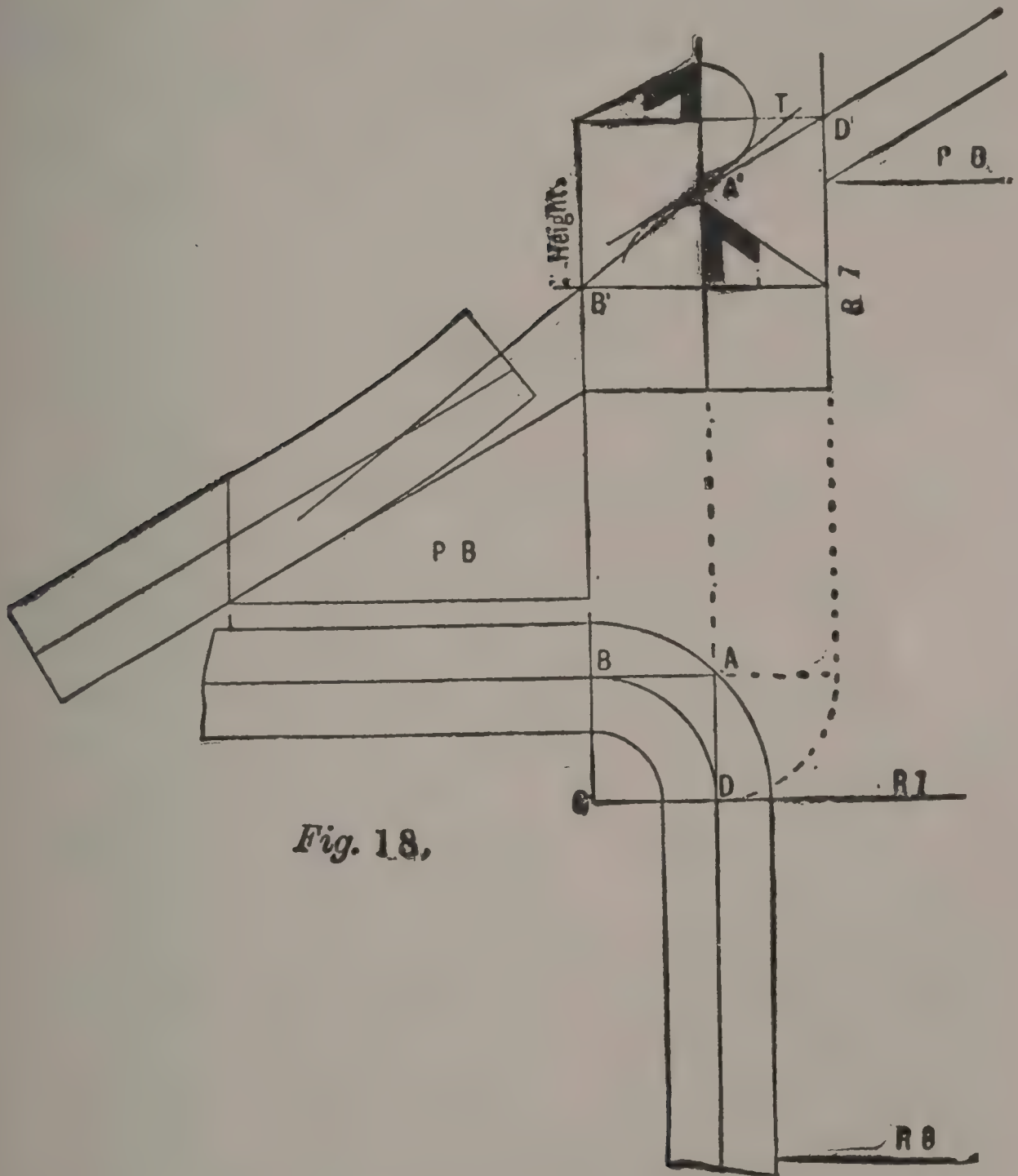


Fig. 18.

$A'D'$ is produced past A' , which is the point where the center line of the lower portions must meet it. It will be seen that if the center line of the lower portion had been produced, it would cut the perpendicular below

A'. Then the pitch must be altered to lengthen as few balusters as possible. This must be done from about the center of the last step, as shown by the pitch-board. Draw the line B'A' as shown. Bisect the angle; draw the joint-line to meet the bisecting line, which is the center the ramp is struck from.

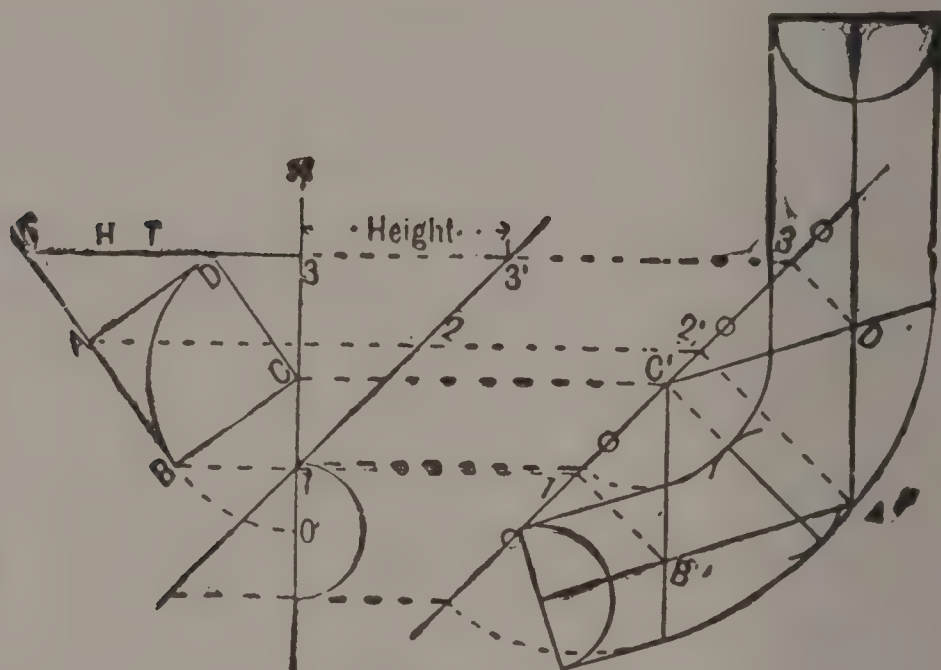


Fig. 19.

Fig. 19 shows the face mould for Fig. 18, obtained in the same way as those for Fig. 1 on the last page.

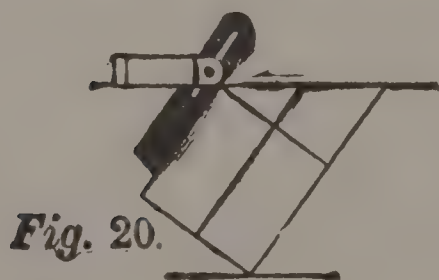


Fig. 20.

Fig. 20 shows how the usual thickness allowed for the wreath is obtained. Where there is a different bevel for each end the one with the more acute angle is used.

Fig. 21 is the plan of center line of rail for a well with six winders, as shown, two of them being in the springing at each side. Draw the tangent lines, the joint line CD, and the springing lines BC, CF forming two squares as shown.

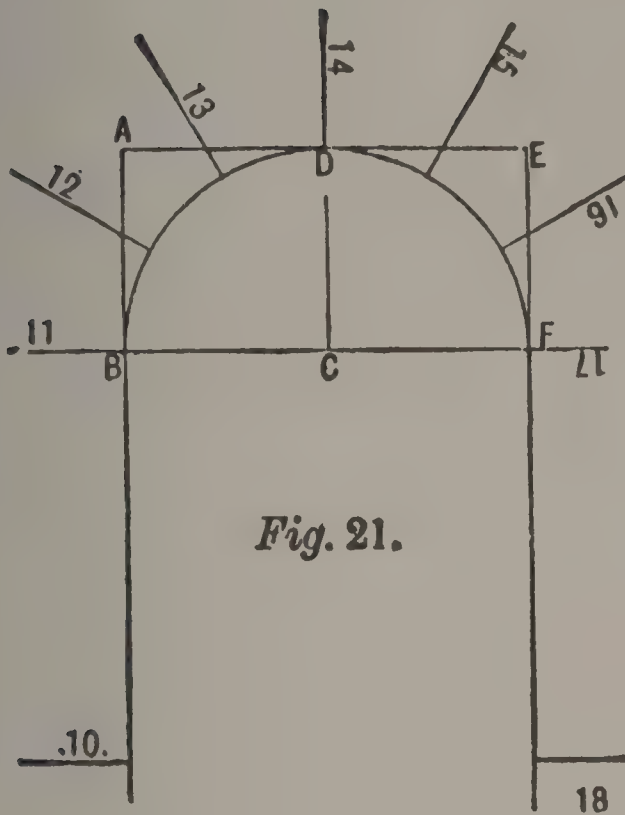
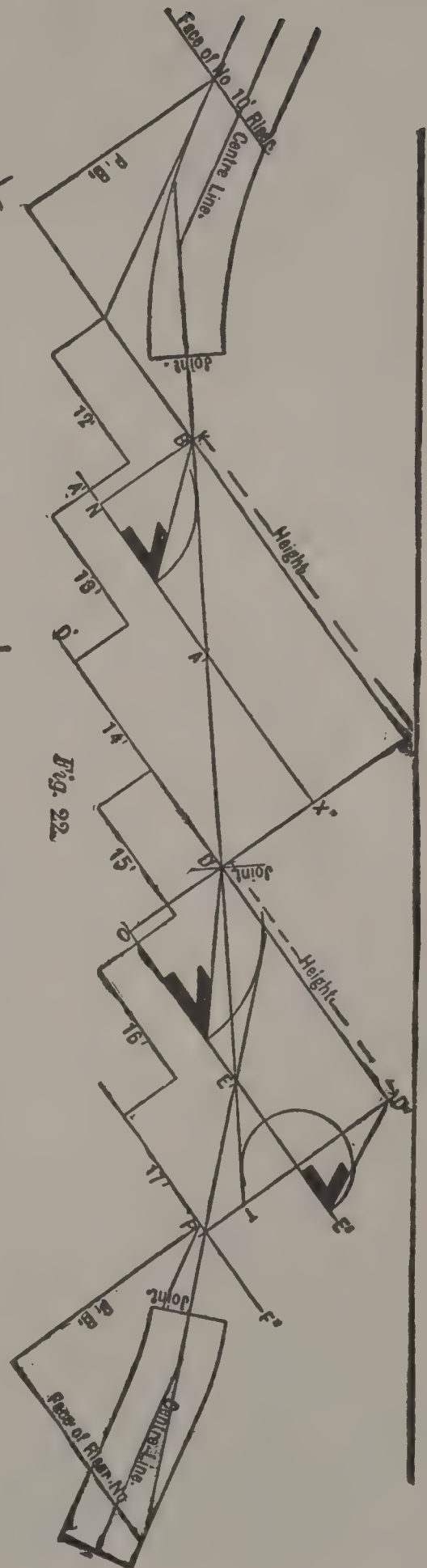


Fig. 21.

Fig. 22 is the stretchout or development of the tangent lines. To draw this let the line LM be the edge of the drawing board; with a bevel set to a convenient angle the end of the winder and riser would give the pitch. Draw the line B'B''; then parallel with B'B'' draw A'A'' at a distance equal to the side BA of the square at Fig. 21, and the same with D'D'', E'E'' and F'F''. Place the pitch-board with its riser side to the line B'B'', as shown, and draw the last straight step. From the top of the riser



draw the line at right angles to $B'B''$ for the first winder. This being the development of the tangents the width of each winder is taken from where they cut the tangent lines at Fig. 21. Then on the first winder from $B'B''$ mark off the distance B to R_{12}^* , Fig. 21, and through the point R_{12}' , with the pitch-board mark off the height of a riser; and through the point draw the line at right angles to $A'X''$ for the second winder. From $A'X''$ mark off the distance A to R_{13} , Fig. 21, and through the point draw R_{13}' the height of a riser, and draw the line at right angles to $D'D''$ for the third winder.

Referring to Fig. 21 it will be seen that riser 14 passes through the point D , then R_{14}' , Fig. 22, is on the line $D'D''$. Mark the height of a riser, and draw the line at right angles for the next winder. The drawing for the top winders up to R_{17}' is just a repetition of what has been done for the others. Then from R_{17}' draw the next straight step, and from the top edge of the pitch-board, top and bottom, set off half the depth of the rail and draw the center line as shown. It will be seen that, if the center line at the top had been continued straight to meet $E'E''$, the rail would be too high over winder 16; then the rail must be lowered at F' , but not more than half its depth. From the center line at about the center of the step, draw the pitch to E' , as shown; draw the pitch $A'E'$ nearly parallel with the winders. In this case it is continued down to meet the center line at the bottom. If this should make the rail too high at winder 13, then the pitch must be lowered at A' , and $A'B'$ drawn to another pitch. Where the pitches meet the center lines at top and bottom, bisect the angles and draw the joint lines square with the pitches, and to meet the bisecting lines which give

* R_{12} means riser 12 on Fig. 21, and R_{12}' , riser 12' in Fig. 22; and so on with these compound references.—Ed.

the centers the ramps are struck from. The joints should be kept clear off the springing lines $B'B''$ and $F'F''$. The ramps may be made any length. The center lines must be marked on the templets and the face of the risers 10 and 12, as shown, and transferred to the ramps. The lengths of the straight rail can be got from these riser lines, and all can be jointed with accuracy.

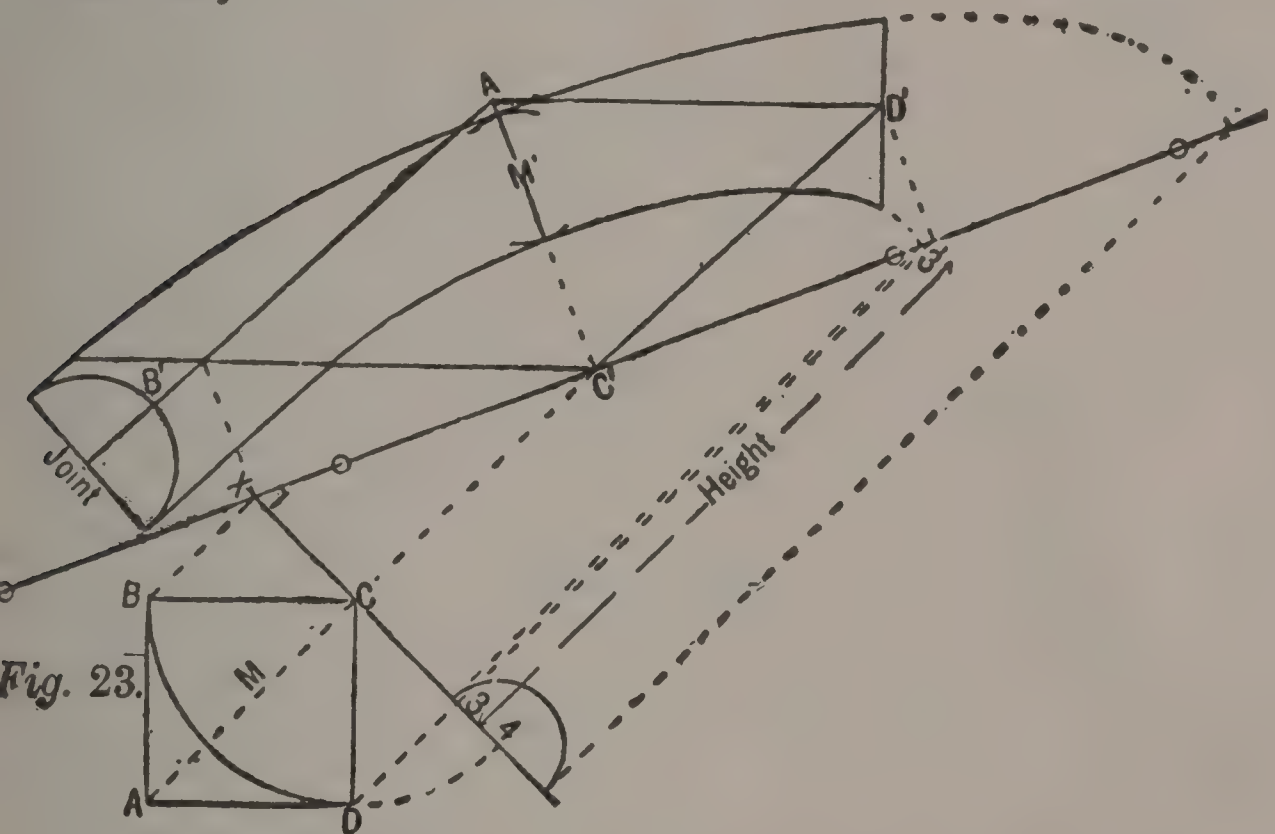


Fig. 23.

Fig. 23 is the face mould for the lower portion, the drawing being similar in every respect to what has already been described. The height is taken from where the pitch or raking tangent cuts the springing line $B'B''$, Fig. 22, to the line drawn at right angles to $D'D''$ through the joint. The pitches being the same, the bevel answers for both ends. Where the line from B' cuts $A'A''$ at N , with N as center, draw the circle tangent to the pitch and cutting $A'A''$. From the intersection draw the line to B' , and in the angle is

seen the bevel. The straight portion of the face mould from B' to joint at Fig. 23 is made the same as B' to joint at Fig. 22.

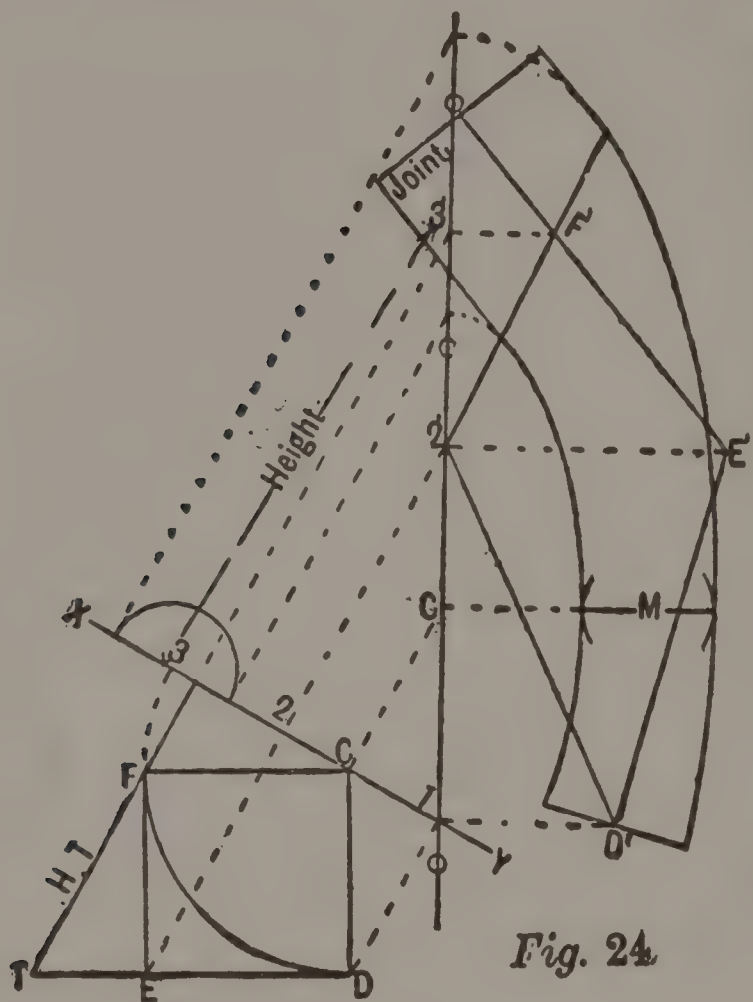


Fig. 24

Fig. 24 is the face mould for the top portion. To find the height where the pitch cuts the springing line $F'F''$, Fig. 22, draw the line $F'F''$ at right angles to D'' ; then to the line at right angles to $D'D''$, through the joint is the height. Where the line through the joint cuts $E'F'$ at O , with O as center, draw a circle tangent to the pitch and cutting

the line $E'E''$. From the intersection draw the line to D' , and in the angle is seen the bevel for the shank end; where the line $F'D''$ cuts $E'E''$ as center draw a circle tangent to the lower pitch, and cutting the line $E'E''$. From the intersection draw the line to D'' , and in the angle is seen the bevel for the center joint. Make F joint, Fig. 24, same as F joint, Fig. 22.

Fig. 25 shows a simple method of finding the bevels, and one which answers in every case. Let LM be the edge of the drawing board. Square over the line CM , and make the line CM equal to the radius of

the center line of rail. Then at Fig. 24, with C as a center, draw an arc tangent to the line $E'D'$; then with C , Fig. 25, as a center and the same radius, draw the arc cutting the edge of the board, as shown; draw from the intersection to C , and in the angle is the bevel for that end of the wreath. Again at Fig. 24, with C' as a center, draw an arc tangent to the line $E'F'$, and repeat at Fig. 25 for the bevel for that end of the wreath. These bevels can be tested with those at Fig. 22, and they will be found to be exactly the same.

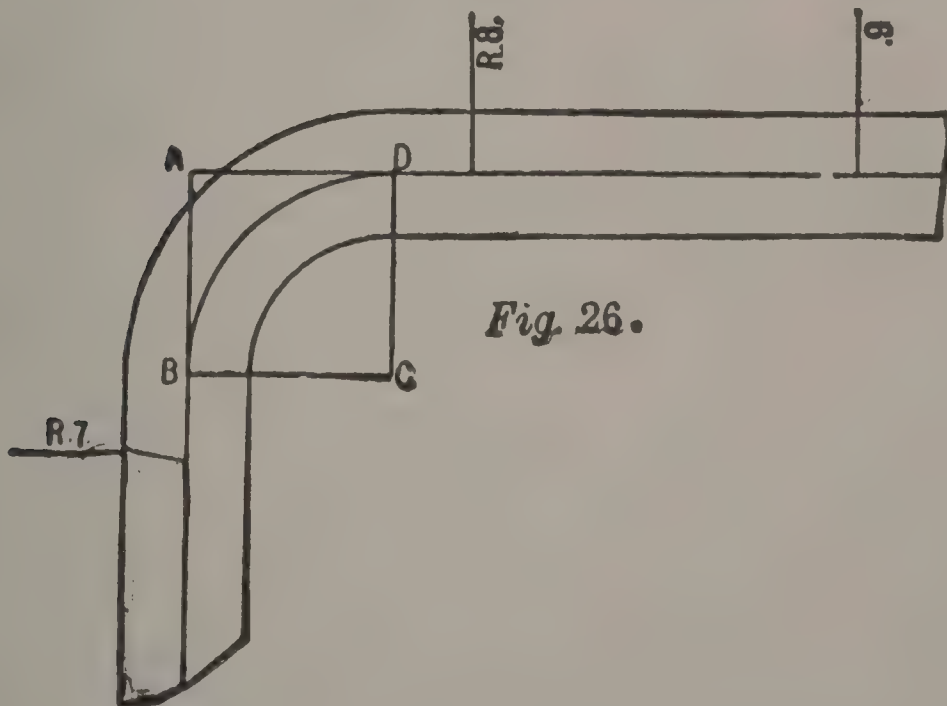
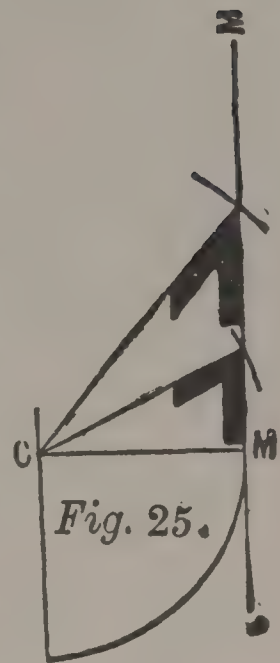


Fig. 26 is the plan of the wreath, showing the risers and tangents.

Fig. 27 is the development, being a repetition of what has been done in previous chapters. It will be seen that the center lines of the straight rails (if pro-

Fig. 29 is an isometrical sketch of the wreath worked into cylindrical form. Cut out the wreath a little wider than the face mould; square through the plank; plane one face true and apply the face

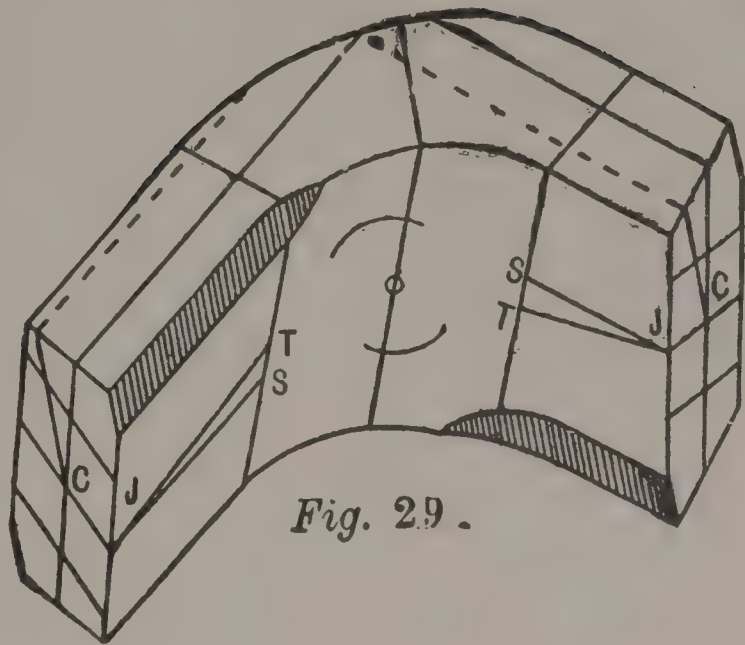
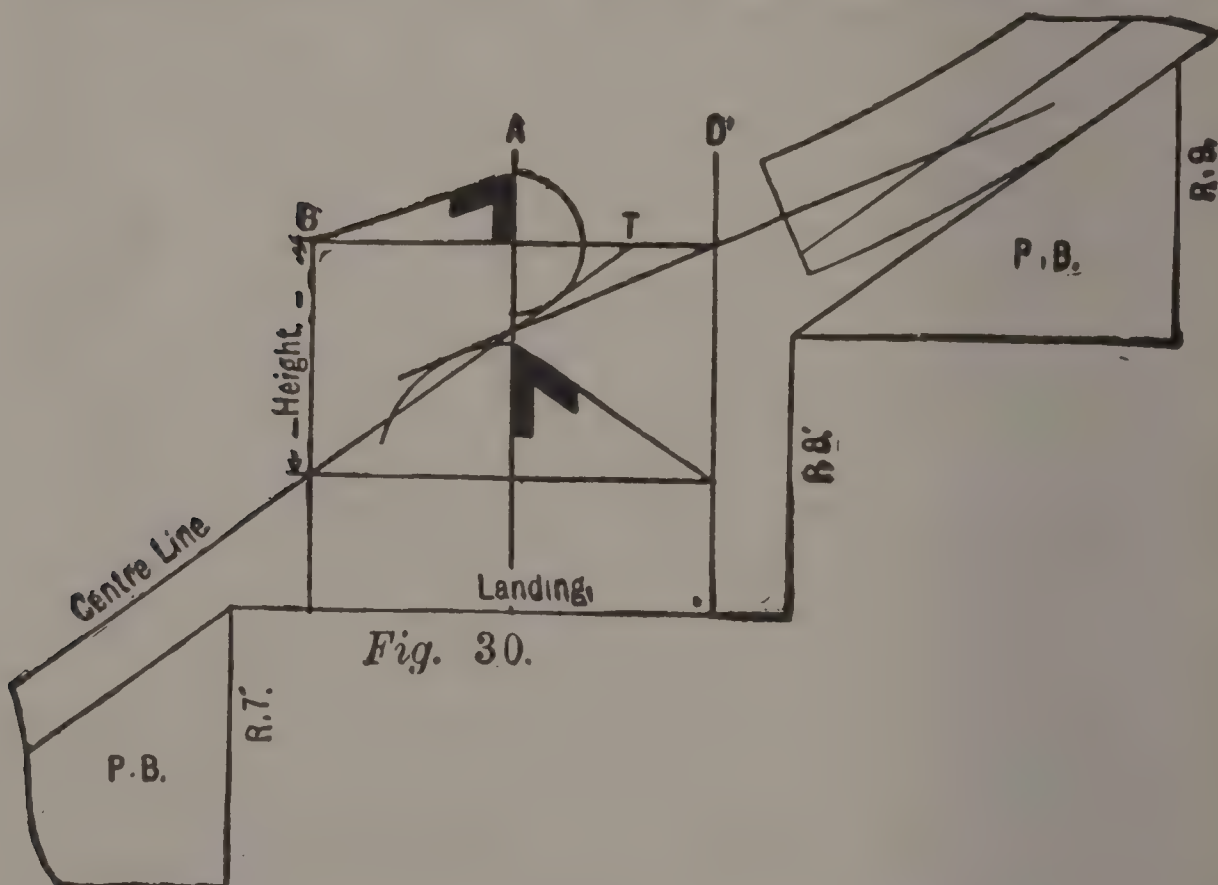


Fig. 29.

mould, marking the joints and transferring the tangent lines to the stuff. Those are represented by the dotted lines. At first the joints are made square to those lines and to the face of the wreath. Square the lines over the ends as far as the center C; then with the bevel, shown at Fig. 27, draw lines across the ends through C. From those lines, draw lines square from the end on each face of the wreath. The tangent lines on the face mould are held to these when marking and working the wreath into cylindrical form. When the face mould is in its position on the wreath (when worked), draw lines across each side of the wreath from the springing and minor axis lines as shown. Draw the line through C square with the line drawn with the bevel. From this line draw square from the end the center line JS on the side of the wreath. Referring again to Fig. 27 it will be seen the center line of the straight rail meets the perpendicular springing line D' at T. Then make a thin piece of stuff to the exact shape of the triangle JST and apply this to the wreath at Fig. 29. With the side JS to JS, and ST to the springing line draw

the line JT, which is the new center line. The joint is then made square to this line and the side of the wreath. This will be repeated at the other end. Then test the height and square the wreath. The shank ends must be worked off as far as necessary parallel to the new center line JT. Should it be necessary to have the shank ends the exact length shown at Fig. 27 the tangent lines on the face mould, B'J and D'J, Fig. 28, would be made to TJ instead of SJ, Fig. 27, to allow TJ on the wreath, Fig. 29, to be the same length as TJ, Fig. 27. This would be immaterial in joining up to straight rails, as the springing lines are drawn across the under side of the wreath and the lengths



are taken from them. For the extra thickness required for this wreath the distance ST, Fig. 27, would be quite sufficient over what is usually allowed.

Fig. 30 is the development for the wreath to be in

one piece with the easing on the straight rail at the top. The face mould is not drawn, being similar to those already explained.

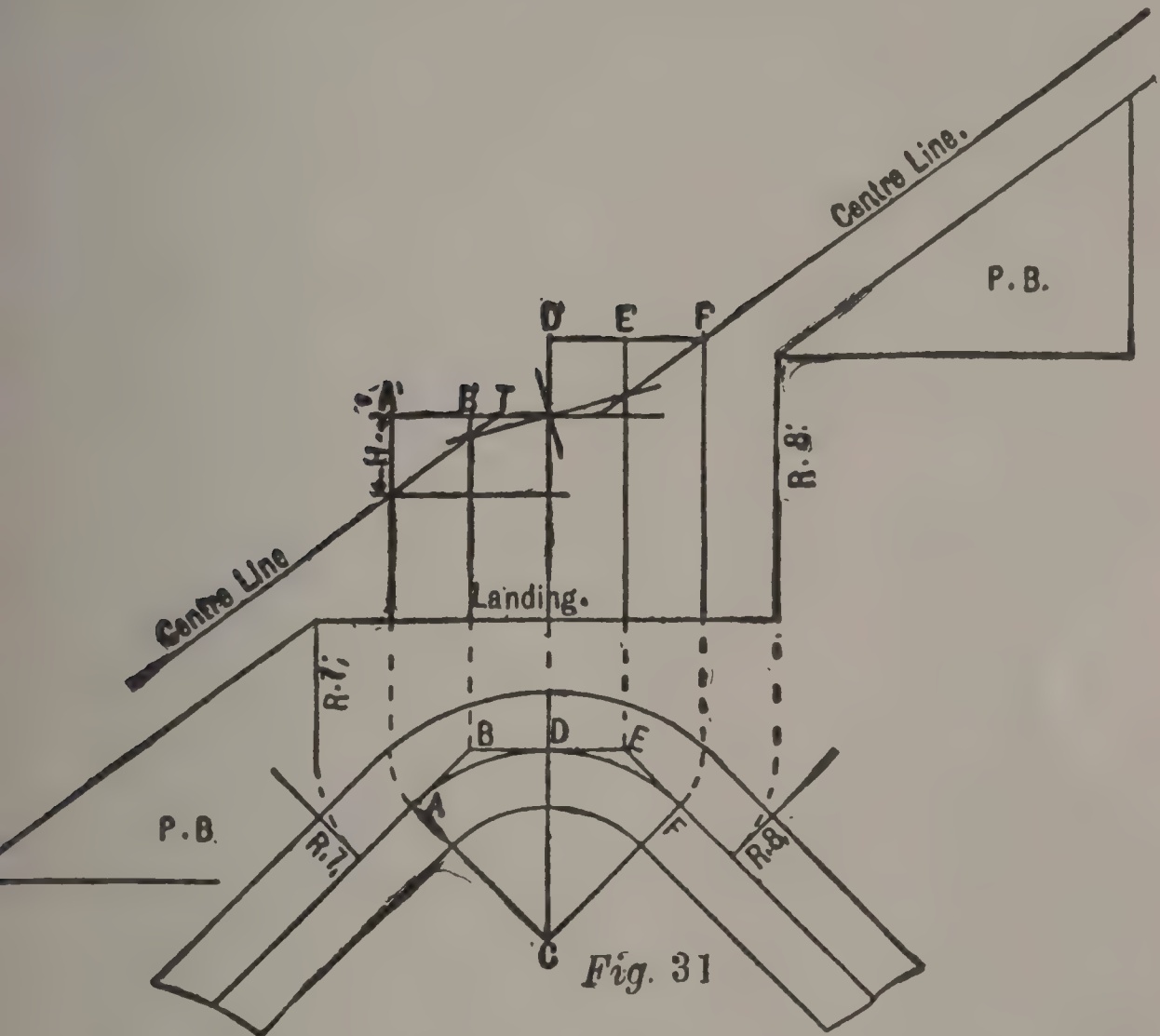


Fig. 31 is the development for the wreath to be in two pieces. Redraw the plan same as Fig. 1; draw the joint line CD, and draw BE tangent to the center line and at right angles to CD. Produce the center lines past A and F to meet B and E. With B and E as centers turn the springing lines around, and project them up parallel with CD. Draw the landing line at right angles to CD; place the pitch-board at R7 and draw the pitch and center line. At RS set up one riser

above the landing; then draw the pitch and center lines. From where the center lines cut the perpendiculars B' and E' , draw the pitch in the center of the wreath, and where this cuts the perpendicular D' gives one point in the height, and the joint is drawn through the intersection, and where the center lines cut the perpendiculars, A' and F' , gives the other points in the heights, as shown by the horizontal lines.

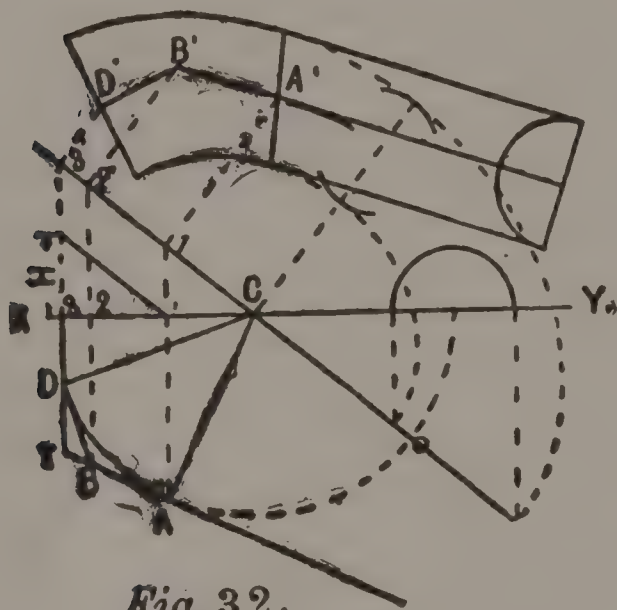


Fig. 32.

Fig. 32 is the face mould. Redraw the center line with its tangents AB and BD ; produce AB to T , making BT same as $B'T$, Fig. 6. Draw the ordinate TD ; draw XY at right angles to TD through the center C and draw projections from A and B , and on TD produced. Set up the height H , taken

from Fig. 6, from where the projector from A cuts XY . Draw the pitch of plank and parallel with this draw the line through C . Where the lines from TD , B and A cut this line draw lines at right angles. Measure on these the distances $1A$, $2B$ and $3D$, join $A'B'D'$ and make the joint square with $B'D'$. Draw the springing line through A' to C and on the line from C set off the radii of the inside and outside of the rail for the minor axis. Turn the center line around to meet XY at O , set off half the width of rail on each side, project these down to meet the pitch-line for the major axis, and draw the curves.

Fig. 33 shows the bevels. Let LM be the edge of a

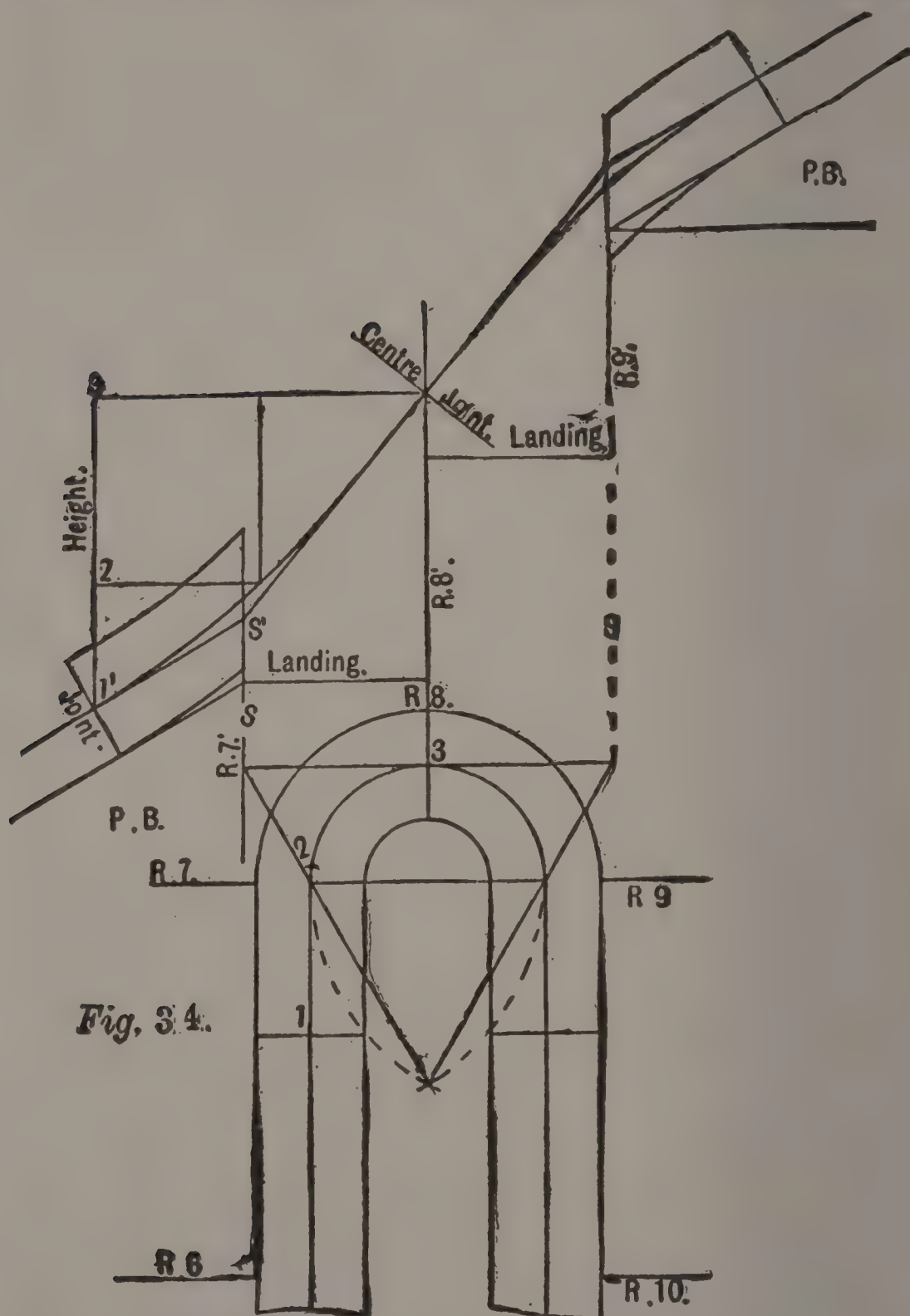
board. Square over a line and measure off on this the radius of the center line of rail CA. Then with C, Fig. 32, as center, draw an arc tangent to A'B'. Then from C draw the arc, cutting LM; draw from the intersection to C, and in the angle is c the bevel for the shank end. Set off half the width of radii on AC; project this up to the top edge of the bevel; take the distance along the top edge of the bevel and set it off on each side of the tangent A'B', Fig. 32. Draw the lines parallel with A'B to meet the springing line. The elliptic curves must pass through these points. The shank end can be made any length. For the bevel at the other end the arc must be drawn tangent to B'D', Fig. 32, and repeated as shown.



In the system of handrailing, known as the section of a cylinder, through three given points, or the face mould plane through three points, the section is determined through an imaginary solid containing on its surface the center line of rail, and its base being defined by the plan of the center line. The following examples illustrate this method:

Fig. 34 is the plan and development of the center line of a rail for a well with two quarter-space landings, the risers being placed in the springing at each side of the well. To draw the development of the center line, draw the equilateral triangle on the diameter of the center line. Produce the two sides to cut the line drawn tangent to the center line and parallel with the diameter. Between the intersections is the stretchout or development, and the perpendicular lines S, S are springing lines. Place the pitch-board with its riser side to the line S at R7; draw the line

along the top edge where it cuts the springing line; draw the first landing at right angles to the springing



line. On the line projected from the center of the well, mark off the height of a riser and draw the second

landing; on the springing line mark off the height of a riser and draw the horizontal line. Place the pitch-board with its tread side to this line, and the point to the springing line. Draw the line along the top edge for the under side of rail and from the top edge of the pitch-board at top and bottom portions, set off half the depth of rail, and draw the center line to meet the springing lines at $S'S'$. Join $S'S'$ and draw the easings between the two lines at top and bottom, and where the line $S'S'$ cuts the perpendicular from the center of the well, draw the joint line through the intersection, also the horizontal line to the left. Draw the joint line at the shank of the lower portion at right angles to the center line. From the center of the rail erect the perpendicular $1'3'$ to meet the horizontal line through the center joint. $1'3'$ is the height the bottom portion of the wreath risers, and also the height of two of the points the section plane must pass through. The middle resting point may be taken in the center of the development for that portion if the shank is short, as in this case, but when the shank is long the middle resting point must be taken in the curve, about one-third the distance between the springing line and the center joint. In this case the horizontal line through the center joint and $3'$ is divided in two and the perpendicular dropped to meet the easing line from the intersection. Draw the horizontal line to meet the perpendicular at 2, which gives the height of the middle resting point the plane must pass through.

To draw the section these points must be determined in plan. From $1'$, in the center of the shank joint, draw the horizontal line to the springing line. Take this distance in the compasses and mark the center line in the plan from springing to the joint at 1. Take the distance

from the springing line to the middle point at the easing and mark the distance from the springing to 2 in the plan; then 3 at the center joint in plan gives the third point.

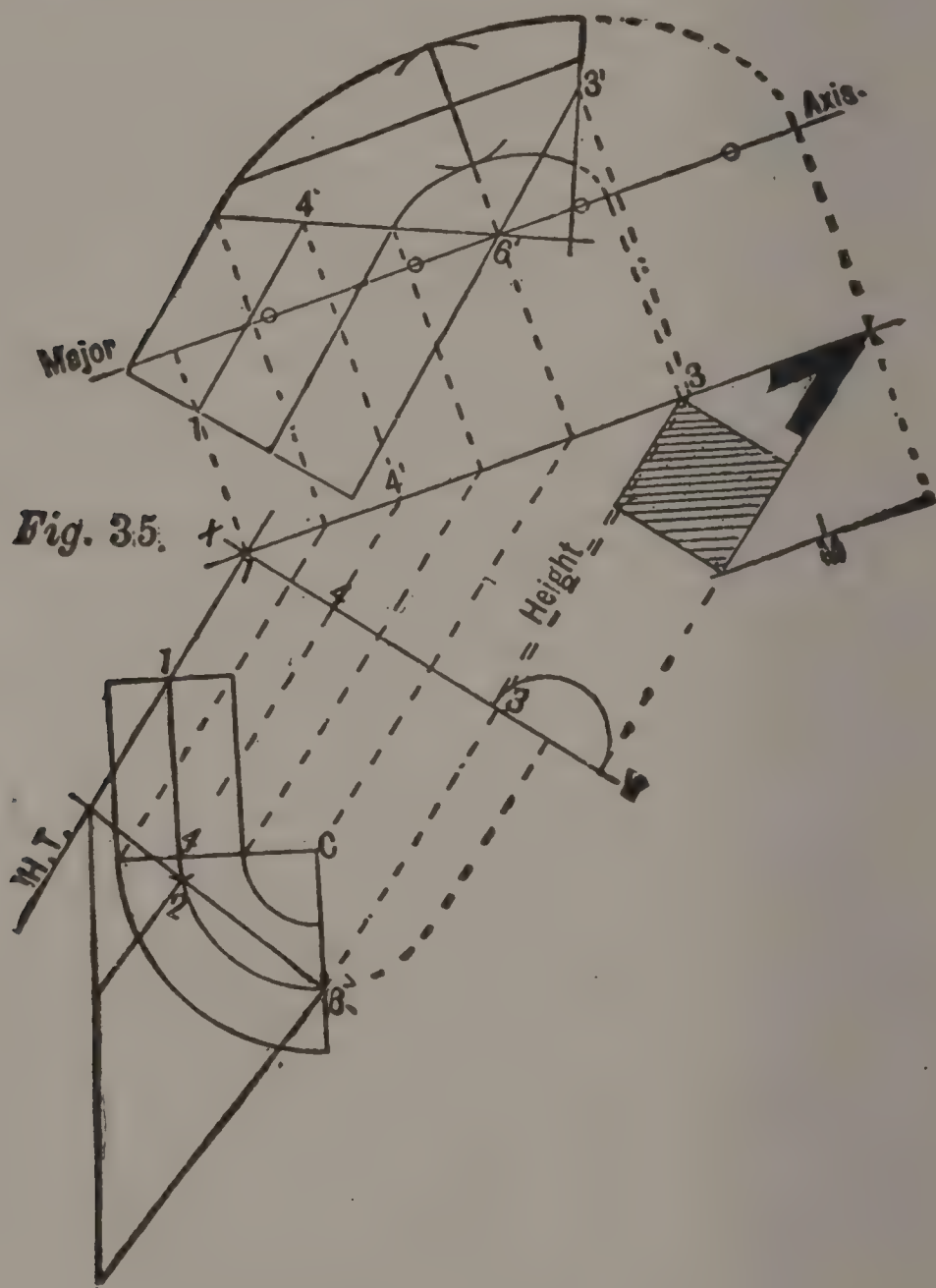
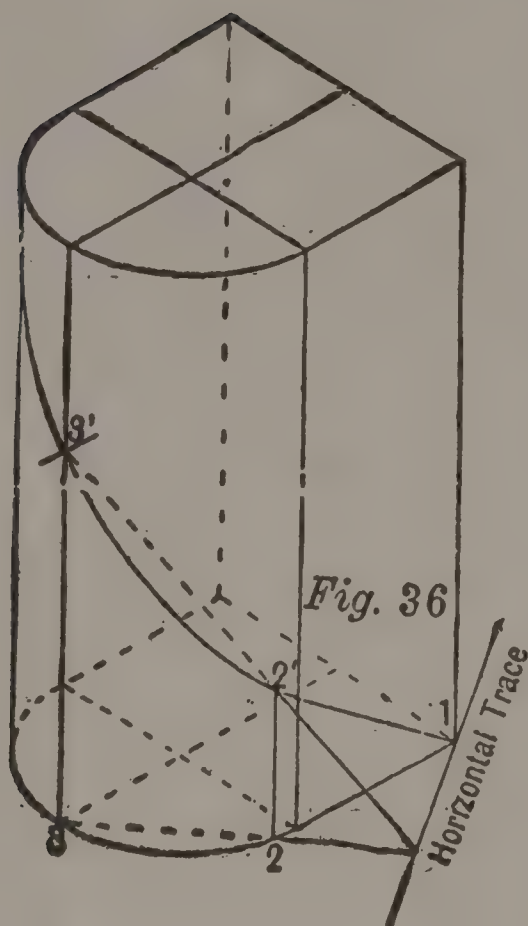


Fig. 35: Redraw the plan with the points as shown. Join 3 and 2, and produce the line to the left and on this line erect perpendiculars from 3 and 2. Make the one from 3 the height of 1'-3' at Fig. 34, and the one from 2 the height of 1'-2', Fig. 34. Draw

a line through the points meeting the line joining 2 and 3, which is one point in the horizontal trace. The point 1 at the center of the shank joint is in the horizontal plane. Draw HT through these points; draw XY at right angles to HT; draw ordinates from the center and each side of the rail at the springing line. Across the rail through C and from 3, at the center joint on the line from 3, set up the height, 1'-3', Fig. 34; above XY draw the lines 1, 3', which is the pitch-line. From where the ordinates cut this line, draw lines at right angles and measure off on these lines from the pitch-line, the corresponding points in plan, measured from XY. The curves may be drawn with the trammel. Turn the center line around and draw the line tangent to it parallel with the ordinates. Set off half the width of rail on each side of this line and project these up to 1-3' and to the major axis line, which gives the semi-major axis for both curves, the semi-minor being on the line. Through C, draw the springing line 4'C', and draw the line through 3'C'. The joints are made at right angles to these produced at 1' and 3', as shown. Draw the shaded section, and the line through the bottom corner shows the thickness for the square rail. In the angle is seen the bevel to slide the mould by. The dotted line from the top point of the bevel cutting the line through the bottom corner of the section gives the whole distance the mould has to slide. Bisect this line at M and draw the line on the face mould through the center of the rail on the minor axis line parallel to the major axis and pitch-line. Apply the face mould to the plank, and cut the piece square through, a little wider than the face mould. Plane one face true and transfer the minor axis line and the line parallel with



the major axis from the mould to the stuff. Square over the minor axis line on both edges and mark the distance from M to the dotted line at Fig. 35, on one side of the minor axis line at the top and on the other at the bottom.

Fig. 36 shows an isometric projection of the cylinder with the lines on the surface.

Fig. 37 shows the face mould in its position when held to the tangent lines. This is known as the square cut.

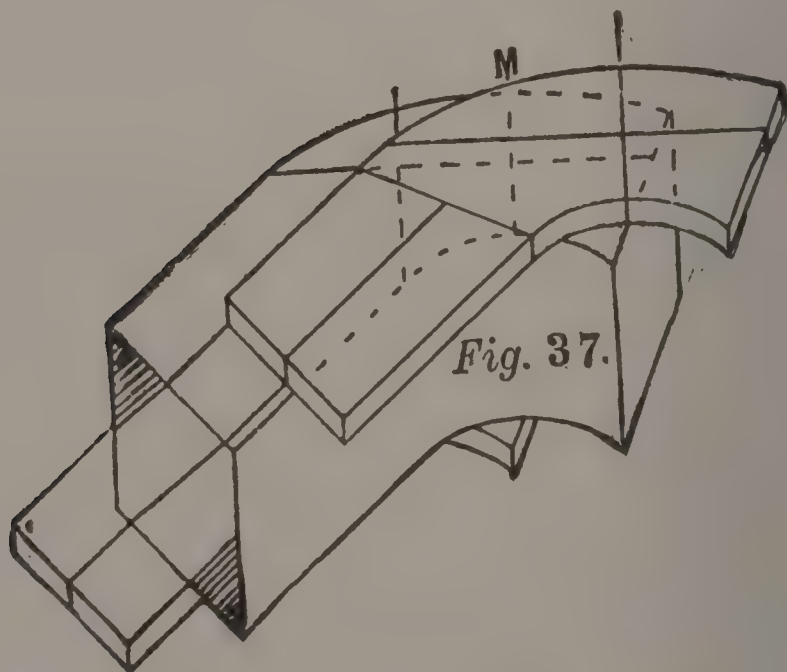
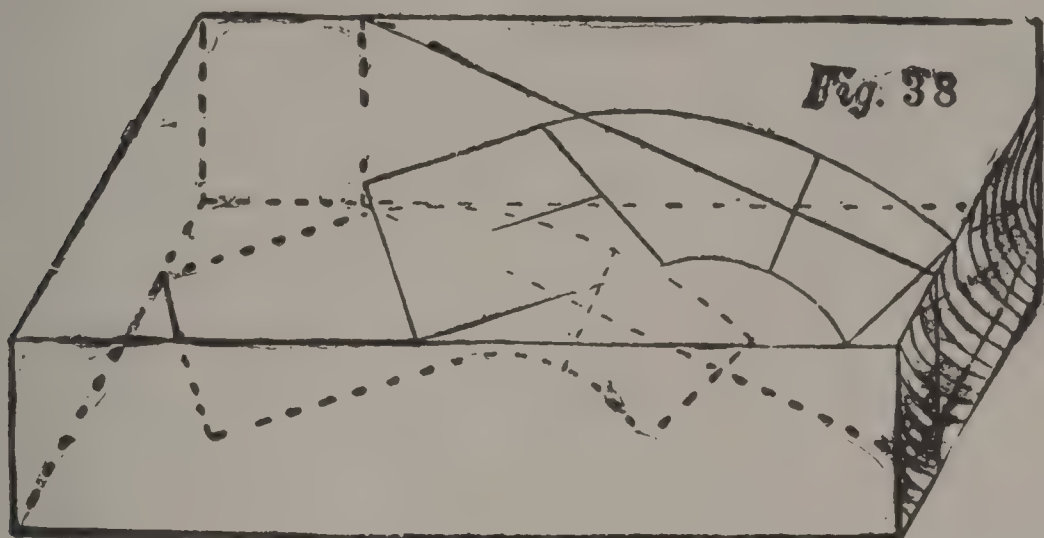


Fig. 38 shows the mould marked on the top and bottom faces of the plank, the mould being moved along

the line on the under side to the distance given at Fig. 35. The wreath is cut out to those lines. This is

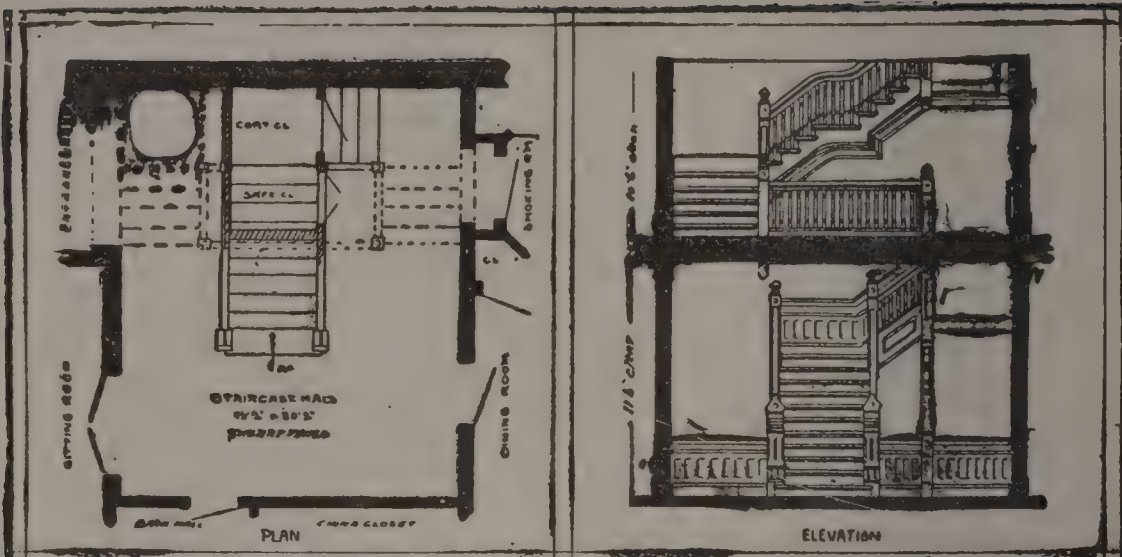


known as the bevel cut. The top portion of the wreath is the same as the bottom. To make the joint at the shank end, it may be necessary to use the short piece of falling mould as at Fig. 34.

This last example is after the system invented by Peter Nicholson, and is, in fact, the foundation of all scientific methods of handrailing, though the system has been very much improved by modern handrailers.

As this little book is intended only for instruction in handrailing, very little has been said regarding the construction of the carcasses of stairs themselves, that subject being left for future consideration, as it was not considered wise to overload this volume with matter not pertinent to the subject in hand, and thus increase its selling price beyond what the workman would care to pay.

It is hoped that out of the numerous examples given, the searcher for instruction in handrailing will find more than enough to compensate him for the outlay of money and time he will expend on this little volume.



INTRODUCTION TO METHOD IV

NEWELLED OR PLATFORM STAIRS

With the introduction of the so-called Queen-Anne and Eastlike styles of building some thirty years ago, the newelled or platform stairs came more and more in vogue, and at the present time more than half the stairs that are erected are of this kind; and this fact has, in a great measure, done away with the necessity of a study of the science of handrailing by every workman who aspires to be a stairbuilder and handrailer. But while that necessity is removed to a large extent, the ambitious young workman should make a successful attempt to master the art of circular handrailing, as it will open up beauties to his mind he never could have appreciated otherwise, and will broaden his knowledge, and enable him to deal with knotty questions of joinery with skill and speed. Platform stairs are easy to construct when once the plan is determined, as newels are placed at the angles, thus doing away with sweeps and curves in the rail, or bending of the strings. They are cheaper than stairs having circular strings, and may be made to have a handsome and impressive appearance. The newels and balusters can assume almost any size and style. The stairs may have open strings, or closed ones to suit the style of architecture. Newels may be massive or slight, "built-up" or made of one solid piece, as may be desired; but where the newels are large, I would advise they be "built up," as a solid newel is likely to check and split and get out of shape.

Stairs of the kind under discussion can be made an attractive feature in a house. Every architect knows this; but no man can build a flight that will be comfortable, or even safe, in a cramped or narrow hall. Stairs are exacting in their demands, and if these demands are not complied with we shall be reminded of the neglect every time we use them. We may resort to make-shifts (if inclined to do so) in other parts of the house, but we cannot put off the stairs with anything and say "it will do," and no coaxing will bring an ill-contrived or badly-arranged flight of stairs into use on any possible terms. A good run is what every flight of stairs requires. If the run is not long enough, then we must increase the height of the risers; and the rise, after it has reached a certain point, becomes trying, then difficult, and at last dangerous. In many houses, in almost all cheap houses, the rise is eight inches. Even the back stairs should not have a more rapid rise, and for the principal stairs this is wholly inadmissible. The other extreme, a fault not often committed, is to have the rise too low.

There are great varieties of rise given to stairs for various purposes, and rules have been laid down for calculating the proportion of tread to riser. A modern writer has given seven different proportions adapted for buildings of different classes. His most ample tread is 12 in. with a $5\frac{1}{2}$ -in. riser; his next, $11\frac{1}{2}$ in. and $5\frac{3}{4}$ in.; then follow 11 in. and 6 in., $10\frac{1}{2}$ in. and $6\frac{1}{4}$ in., 10 in. and $6\frac{1}{2}$ in., $9\frac{1}{2}$ in. and $6\frac{3}{4}$ in., concluding with 9 in. and 7 in. We may say that a 9-in. tread is about the least that is usually allowed in practice when there is any attempt made to study ordinary comfort, although we have met with 8-in. risers and 8-in. treads in suburban villas, which, of course, gives

an angle of ascent of 45 deg.; while in the seven foregoing proportions this angle varies between 24 deg. and 37 deg. It is often expedient, however, to make it lower than 24 deg. With regard to rules for calculating the proportions of steps, some persons maintain that the tread and riser added together should equal 18 in. This would give 13 in. and 5 in., 12 in. and 6 in., 10 in. and 8 in., and 9 in. and 9 in., and in the two latter proportions the rise is too great. Others say that the tread and riser multiplied together should equal $17\frac{1}{2}$ in., which will give 13 in. and about 5 in., 12 in. and $5\frac{1}{2}$ in., 10 in. and $6\frac{3}{8}$ in., 9 in. and $7\frac{1}{3}$ in., and 8 in. and $8\frac{1}{4}$ in. This rule gives better results than the former. Whether the risers are high or low, they must all be of a uniform height. Any departure from this rule is always attended with mischievous results. If all the risers in a flight are seven inches, with one exception, and that one is either six or eight inches high, every person who passes up or down will trip at that step. No matter how often he goes up or down, he will always trip at that point.

The practical difficulties in arranging stairs to rise from one level to another with a sufficient tread and a commodious headway are often great, while in construction awkward problems are frequently suggested from the necessity of carrying flights of stairs over spaces where they can neither be well fastened into the side walls nor supported from below. Not only do these practical difficulties have to be considered in every class of staircase, from that of a cottage to that of a palace, but in all situations where the stairs form a conspicuous feature and where there is any pretense at ornamental building, its artistic treatment affords ample scope for the skill of the architect or the work-

man. Stairs of this kind, to be effective, should be wide between the wall and rail, with one or two flats or landings. The rail must be heavy, the balusters something more than "broom handles," and at the foot let there be a newel, on which the architect may display his taste and skill. It need not be elaborate, but it is a conspicuous object, and it should have something more to recommend it to our notice than the cheap and stereotyped forms, which may be bought at the turner's by the hundred. As a first and most essential principle, a staircase should present an inviting aspect, suggestive of an easy ascent, not of a painful and laborious effort at climbing. Therefore, even if it were, as a rule, possible, which it rarely is, to arrange several flights in a direct line, it would be undesirable to do so; for, however imposing the effect of such an arrangement, it could not but oppress those about to ascend it with an uncomfortable sense of coming fatigue, suggested by the prospect of one long ascent, broken only by landings which would be lost to view from the bottom.

It is pleasant to mount up stairs properly planned, especially if they are well lighted and ventilated. And if on the first landing the architect can contrive a bay, deeply recessed and provided with seats beneath the wide windows, he will, by so doing, add another charm to the house. Here, those who are advanced in years, and who find it difficult to climb one flight at a time, may rest awhile, or sit and chat. Here the little ones love to pause in their passage up and down, and here flowers growing in a *jardiniere* in front of the window, may send their fragrance through the house.

Stairs may be of wood, stone, marble, brick, terra cotta, iron, or iron and concrete. The arrangement

and construction of staircases forms one of the most important, and often most difficult branches of architecture and building.

Modern stone steps are either solid or formed with treads and risers. It was the latter mode of construction that probably first suggested the nosing which is found in the buildings of the Italian renaissance, erected during the sixteenth century. It is quite clear that stone stairs of the tread-and-riser construction require firm support at each end, and it is for this reason that they are seldom used except in basements. Most stairs, whether in stone or marble, are usually solid, and depend for support upon being tailed into the wall at one end, and being connected together with bird's-mouth joints, by which means each step is sustained in position by the one immediately below it, so that the thrust of an entire flight is transferred from top to bottom. In wide flights—those exceeding 4 ft. in width—it is often expedient to strengthen the connection of the stairs by means of a flat bar of rolled iron fixed to their ends with small bolts let into the stone and run with lead. Sometimes a bar of rolled L iron is placed so that its bottom flange is under the soffit of the stairs; and sometimes it may be connected with the balusters when they are affixed to the outside of the stairs, after a French method that has been introduced with the object of gaining more space upon the stairs; but, in any case, it is not difficult to impart an ornamental character to the iron stiffening bar, or to the screw nuts that hold it in position. When, as in some cases, the stairs cannot be tailed in a wall at either end, it is common to pin them in between the flanges of a raking riveted girder or a rolled I joist or channel iron.

The variety of materials now used for staircases has given rise to many different methods of construction. Many modern methods of treatment have been derived from stone forms, for the oldest specimens that remain to us from antiquity are of stone. The Greeks and Romans appear to have treated the staircase purely as a utilitarian accessory to a building, and not as in any way to be regarded from an aesthetic standpoint. Among all the builders of antiquity the Assyrians and Persians best understood the imposing effect produced by vast flights of steps, as may be gathered from the remains at Nineveh and Persepolis. But the ancient modes of construction were very simple. For the most part the flights of steps were carried upon solid masses of masonry, or occasionally upon vaults, when the space underneath was to be utilized. The steps were perfectly plain, without nosings, and the modern bird's-mouth joint was conspicuous by its absence.

Much the same may be said of mediaeval staircases. In earliest forms of spiral turret staircases, a solid newel of masonry was built up in the center, and from this to the walls was thrown the vaulting, which was carried up in a spiral form, and upon which the steps were laid without being bonded either into the newel or the wall. In later examples the steps were tailed into the walls, while their smaller ends, being cut to circular form upon plan, were built one upon the other, so that they actually formed the newel.

While these few hints regarding the uses of materials other than wood for construction, are presented herewith, it is not the province of this essay to deal in other than wood in the construction of stairs. In another volume, stone, iron, concrete and terra cotta will be talked over in their relations to stair constructions,

In the following pages I have endeavored to show by illustrations and descriptions a variety of designs for platform stairs, so that almost any taste, or any style of building may be satisfied. I have also added some useful memoranda, which I feel assured will be welcomed by all workmen having stairs to build.

Most of the illustrations presented are from American examples, though I have thought it proper to exhibit a few of the curious or elaborate platform stairs from the Old World, not so much as specimens to follow, but simply to show to what extent of labor and ornamentation the old workmen went to satisfy their taste.

FOURTH METHOD

EXAMPLES OF PLATFORM STAIRS

It may seem lost effort to tell the workman that one of the first requisites, and the most important one, is that the carriage of a flight of stairs be built strongly and with timbers of such a dimension that any ordinary weight that may possibly be taken over the stairs will not cause the timbers or strings to "sag" or bend under the load. Often pianos are taken upstairs, and these may have a weight of anywhere from 350 to 1,000 pounds, or more, and this stair, with the weight of four or five men added who will be required to assist in getting one of these bulky instruments upstairs, will increase the weight considerably. The framework of a stairway should be made to resist a stress of not less than two tons. Strings for flights having ten or less treads, should never be less than 14 in. wide and 1½ in. thick, and these should be re-enforced by rough-cut strings 10 or 12 in. wide and 2 in. thick. One of these rough strings should be spiked or screwed to the inside of the open string, and another similarly fastened to the wall or housed string, and one or two of these strings should be placed at equal distances between the open and wall strings. The rough strings should fit accurately against both tread and riser in order to get the best results. Flights of greater length should have stouter strings and more bearing pieces. If the outside string is supported with a partition running to the floor, or the stairs have a cross partition,

half way in their length, then the timbers need not be so heavy; but, it is always better to err on the side of strength and rigidity than to have the frame of a stair weak and frail.

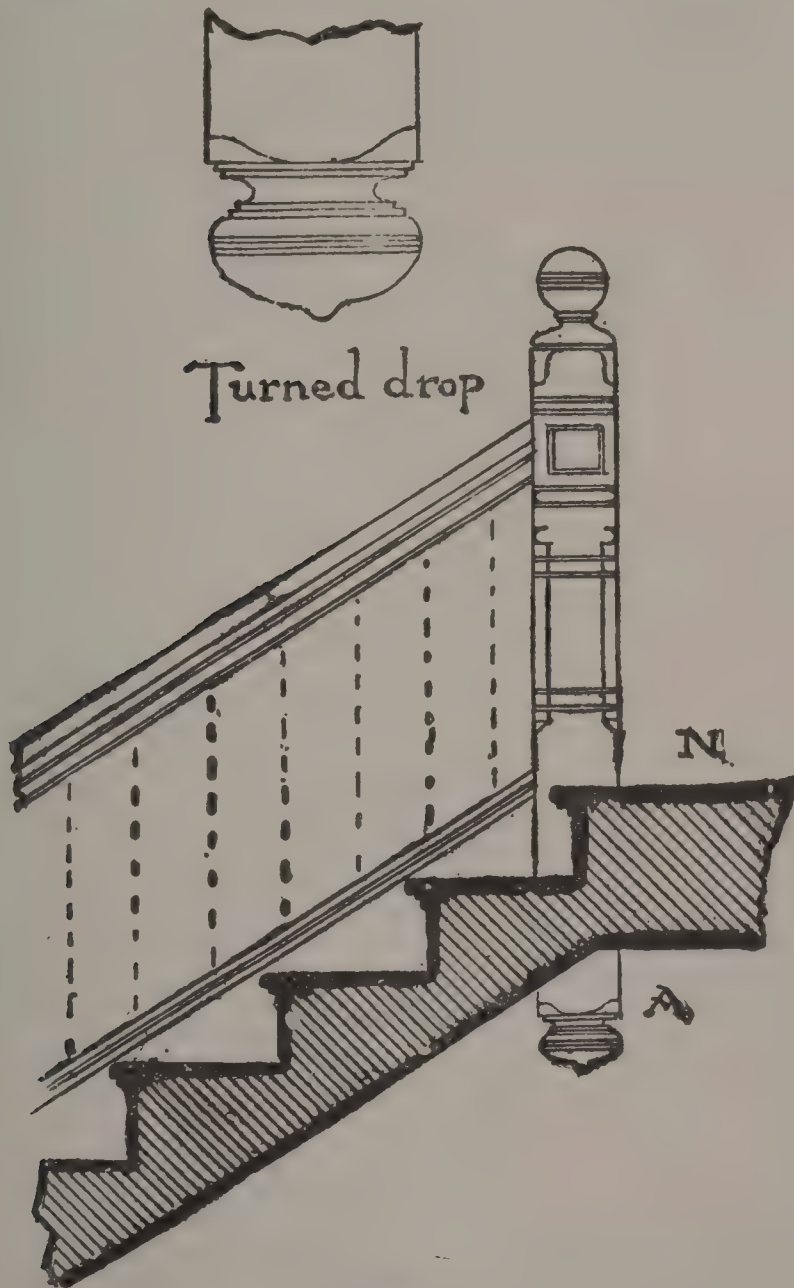


Fig. 1.

PLATFORMS

When the plan of the stair will permit, it is always better to have a platform. A platform built on posts

which reach down to a solid foundation at the **lower** floor, or below, if necessary, is always the best. Posts may be halved at the top to receive joists or joist-bearers; or timbers may be tenoned into the posts. I prefer halving, however, as then we get the whole strength of the bearing pieces. In all cases, provision **must** be made for the proper fastening of the **newel**

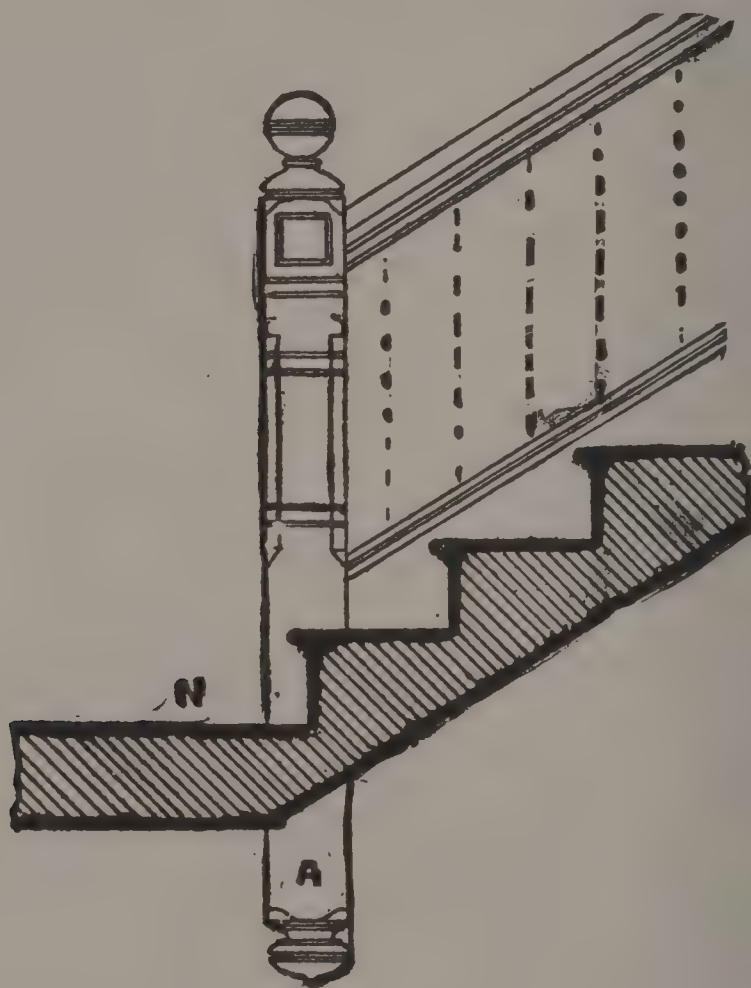


Fig. 2.

posts at the corners, and, if circumstances will admit of it, the shank of the newel post should run down below the timbering of the platform as shown at **A**, Fig. 1, and on larger scale above the newel. In this figure the string is shown, also the lines of balusters. There is a sub-rail in this example, which is placed just

above the line of nosings. A device of this kind allows a broom or brush to sweep clear through to end of step, to clean off dust without being obstructed by balusters. The platform is shown at N which may be continued to suit conditions. A lower platform which may belong to the same stairs is shown at Fig. 2. Here I show the drop of the newel A, reaching down further than the one in Fig. 1. The platform N may be extended to any length suitable to the requirements. Newels running down in the angle formed by the angle of the apron of the platform and the outside string, should be well secured to both the timber of the platform and the string. This can best be done by inserting a handrail bolt in the newel and leaving the end projecting out to pass through the timber, and another one should be placed so that it will pass through the string. Sometimes the newel is placed in position before the string is put up, and the center line of balusters is made to coincide with the center line of the newel. This is an excellent method if the stairs are open under the string, for then the "drop" can hang below the apron and string. The newel can be gained out to the proper depth over the joists, and the apron can be fitted in nicely to build against the shank of the newel post.

AN OPEN NEWEL STAIR

I show, at Fig. 3, the ground plan of an open newel stair having two landings and closed strings. The dotted lines show the carriage timbers and trimmers, also the lines of risers; while the treads are shown by complete lines. It will be noticed that the strings and trimmers of the first landing are framed into the shank

of the second newel post which runs down to the floor, while the third newel drops below the apron and has a turned and carved drop. This drop hangs below both apron and string, as shown in Fig. 4. The lines of treads and risers are shown both by dotted lines and etched sections. The position of the carriage timbers

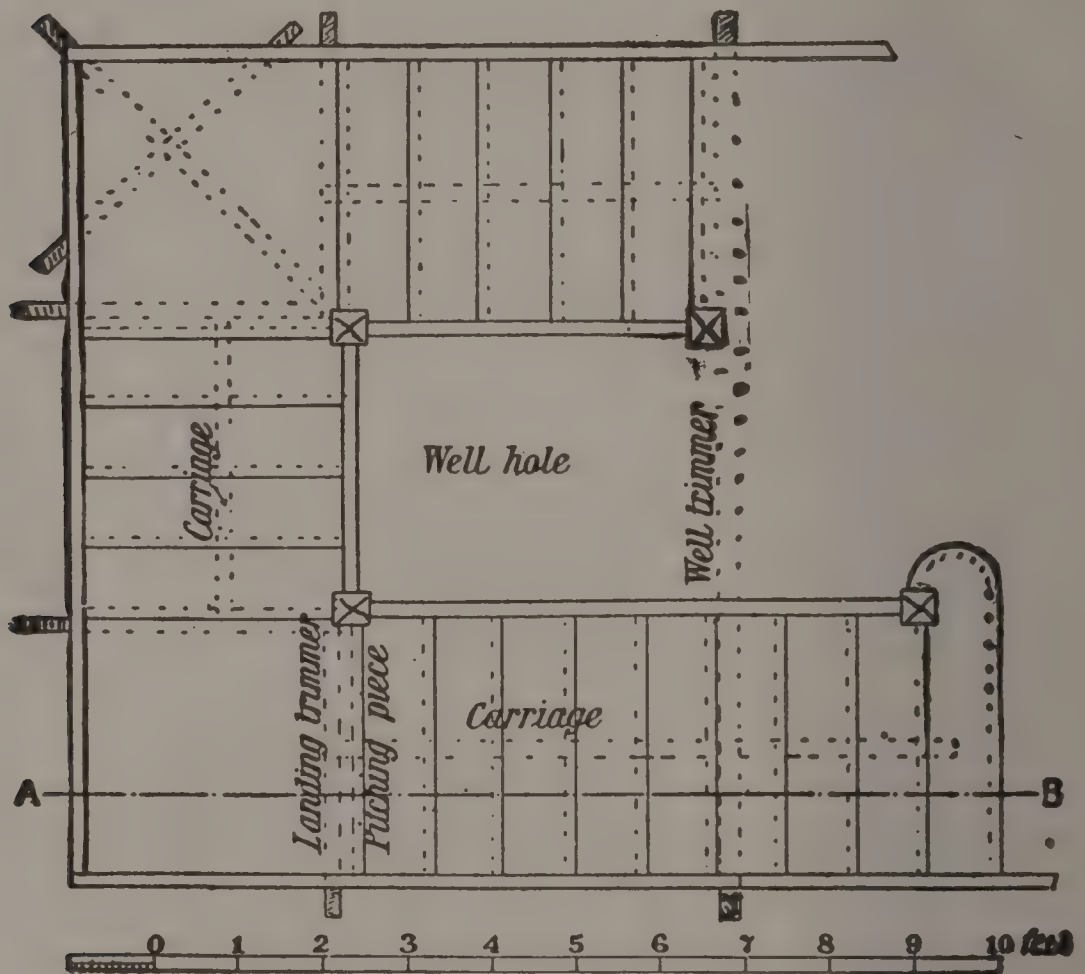


Fig. 3.

is shown both in landings and run of stairs, the projecting ends of timbers are supposed to be resting on the wall. A scale of the plan and elevation is attached to plan.

Fig. 4 shows the elevation in full with a story rod shown on the right, with the number of risers spaced

off. Design of newel, spandrel, framing and paneling is shown, also "raking" balusters.

Only the central carriage timbers are shown, but in

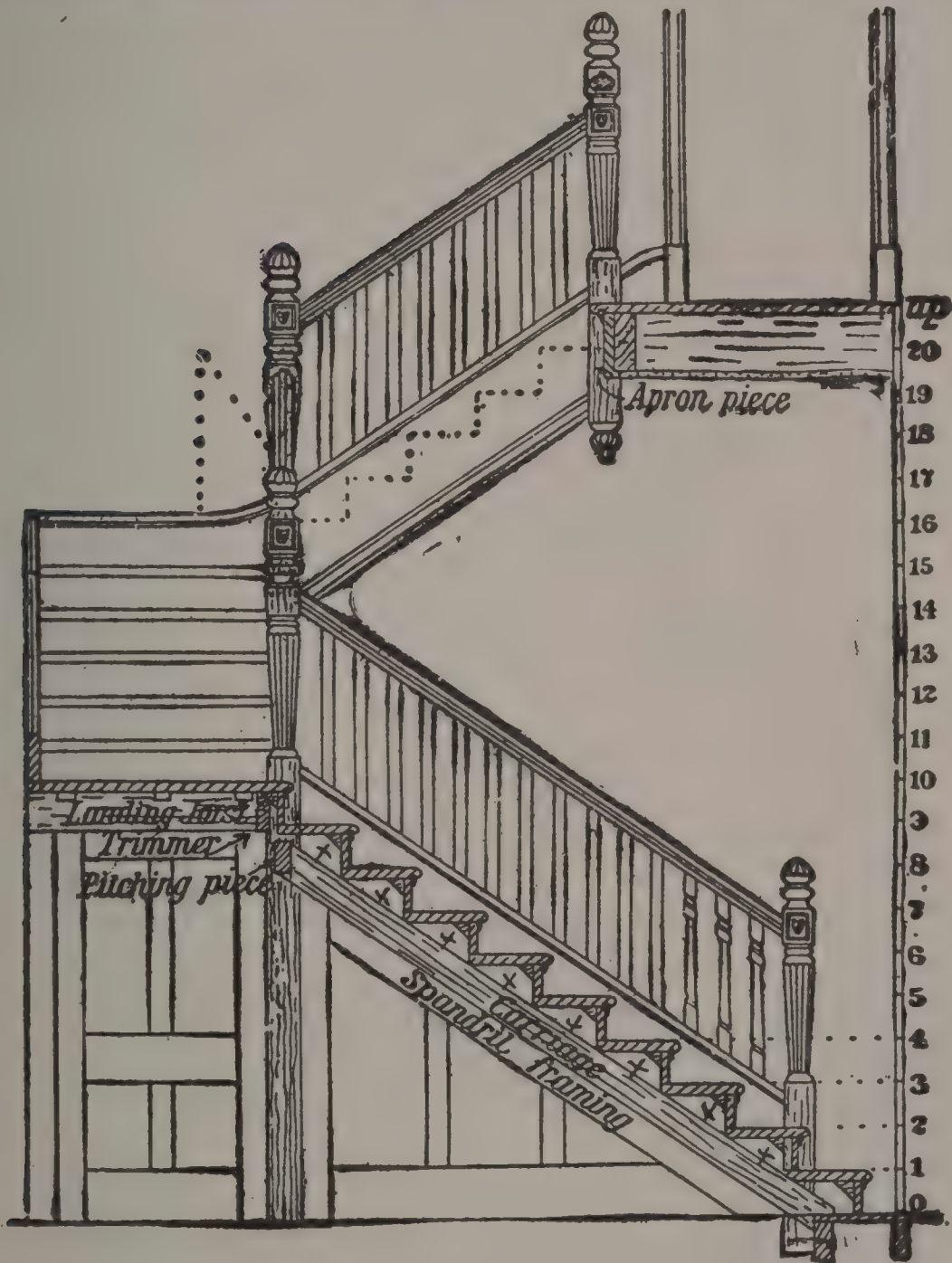


Fig. 4.

a stair of this width there ought to be two other timbers, not perhaps so heavy as the central one, yet strong enough to be of service, also to help carry the

lath or paneling which may be necessary in completing the soffit. The strings being closed, the butts of the balusters must rest on a sub-rail which caps the upper edge of the outer string.

The first newel should pass through the lower floor and should be secured by bolts to a joist, as shown in the elevation, so as to insure solidity. The rail is attached to the newels in the usual manner with hand-rail bolts or other suitable device.

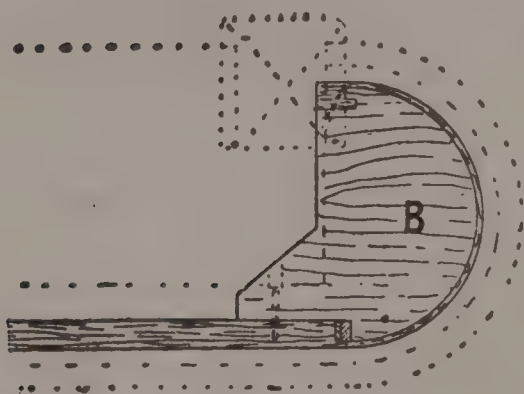


Fig. 5.

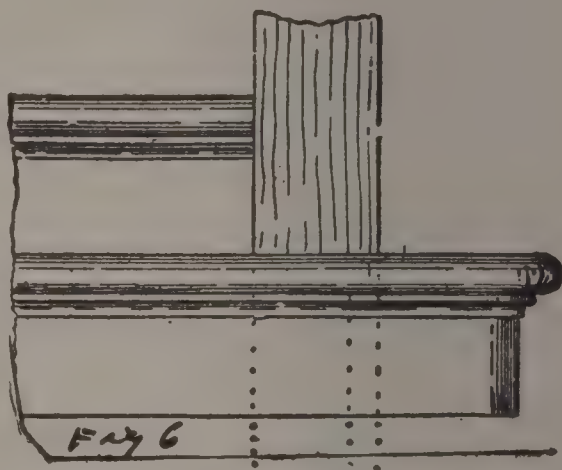


Fig. 6.

The sketches shown at Figs. 5 and 6 exhibit the end of the bottom step, which is semi-circular or "bull-nosed," also an end view of the lower tread and riser with the shank of the newel passing through. The position of the newel, with regard to the step, is shown by the dotted lines in Fig. 5.

The block B may be made from one solid piece of stuff or built up in layers and the face covered with a thin veneer, as shown in the illustration; and this finish is then the face of the riser. The nosing on the tread is worked on the end of the stuff, and the cove under the tread is worked on the end of the stuff, and the cove under the tread may be worked from the solid,

or it may be sprung in place if made of some elastic wood and steamed.

An examination of Fig. 4 will reveal the fact that blocks XXX are glued or otherwise fastened in the angles formed by the junction of the treads and risers. These blocks may be beveled off as shown, or they may be left simply as square blocks. This device is to give rigidity to the work. These blocks should be put in between the carriage pieces, as the latter should, when possible, fit snug to both tread and riser and go well into the angles.

Sometimes in landing stairs the rail finishes in a cap at the top of the newel; in such cases, the cap is turned, having its edge made in the same shape as the edge or moulding of the rail, as shown at Fig. 7. When this is the case, some special manipulation of the cap is necessary to have it fit properly, as shown at Fig. 8. The method of finding the proper shape of the cap is shown at Fig. 9. The

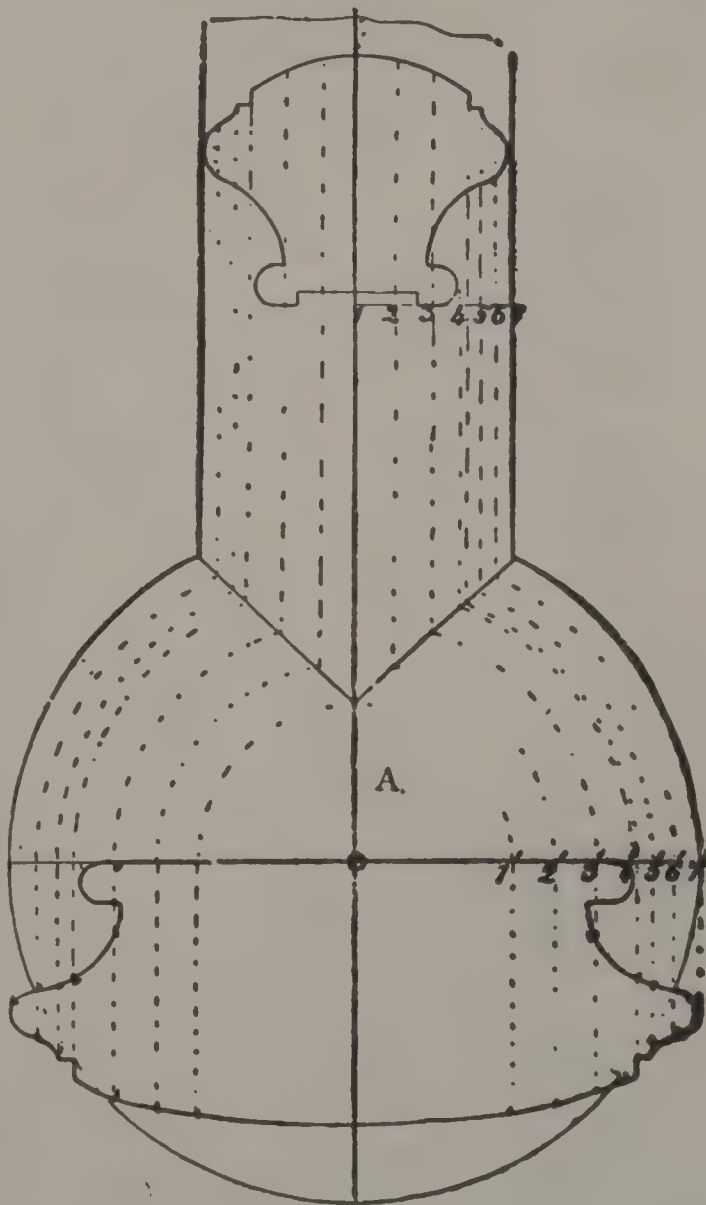


Fig. 7.

upper section shows the rail, which is supposed to be the full size; the lower section shows the cap, which may be of any reasonable diameter. Draw the plan of the cap as shown, then a section of the rail, then draw



Fig. 8.

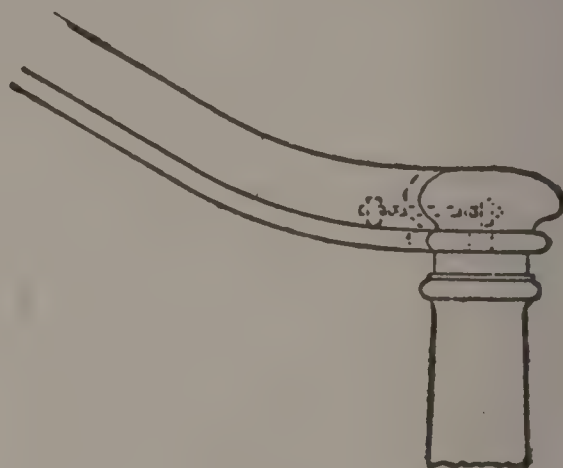


Fig. 9.

the joint or miter lines as shown, and from the outside points of these lines draw parallel lines with the central line A. Divide into spaces as shown by the dotted lines, then at the junction with the miter lines describe semi-circles as shown, until they cut the line of diameter. Square down these lines and from them prick off the points as figured, and through these prick points describe the curves and squares; then, when mitered with the rail, there will be no over wood to remove.

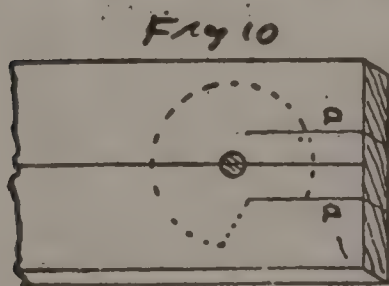


Fig. 10.

To cut the miter on the cap, first prepare a cutting block similar to that shown at Fig. 10, which may be made from a piece of stuff 2 or 3 in. thick and planed true

on the face. Gauge a center line upon it and insert a dowel that will fit snugly in a corresponding hole in the cap. Next saw two kerfs in the block parallel with the gauge line, as shown at *aa*, and at a distance from the latter equal to the square distance of the miter line *a* from the center of the cap *c*, Fig. 8. The depth of the saw cuts below the edge of the cap, which is shown by the dotted line in Fig. 10, is made equal to the length of the miter line, as shown in the plan Fig. 8. The width of the rail is marked upon the edge of the cap. The latter is then placed on the dowel and turned around until one of the marks lies against one of the saw kerfs. The saw is then run down to the bottom of the cut, and the cap turned until the other line lies on the other kerf, when the saw is again run in to meet the first cut, which finishes the miter complete. The foregoing method is the best and most economical for fitting the rail to the cap, but sometimes it is required that the joint shall be a true miter, which may necessitate some different treatment in forming the section of the cap. This is shown in Fig. 7, where full directions are given for laying out the lines for this kind of a cap

STAIR STRINGS

It is hardly necessary for me to say much about forming a pitch board by which stair strings are laid out, but as many of the readers of this book will be beginners in the art of stair-building, it may be well to devote a small space to this subject.

A pitch board is simply a piece of thin board, or other suitable material, and is in itself triangular. It is so cut as to represent the rise of the step and width of tread proper. The third or long side being the

“run” or “going” of the stair. A sketch of one is shown in the shaded portion of the string, Fig. 11, and its application. The dotted line running through the pitch board shows the line of nosings, and the third edge or “run” of the board. The piece below this line O is a gauge or guide which is necessary to the board, for a quick laying out of treads and risers. It will be seen that the height of the riser is laid off on one edge of

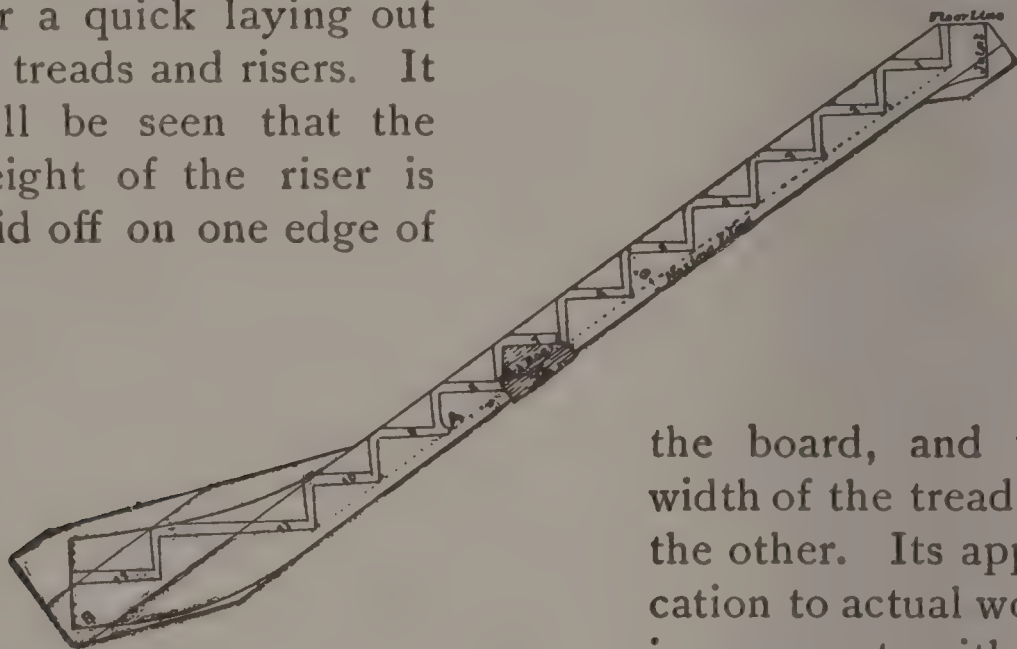


Fig. 11.

the board, and the width of the tread on the other. Its application to actual work is apparent without further explanation.

The string shown in Fig. 11 exhibits a wide tread at the bottom, a circumstance that sometimes happens—though a change of pitch should always be avoided where possible—and the string is widened out by having pieces glued to it, so that it can be “eased-off” with a gentle curve, as shown. There is also an “ease-

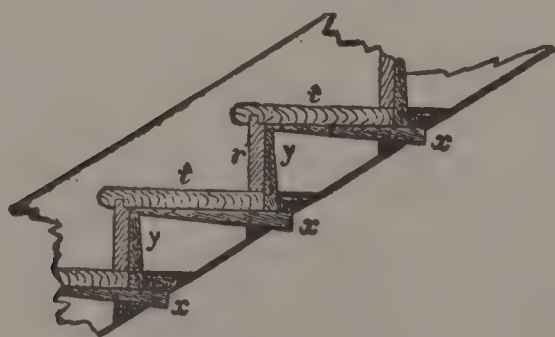


Fig. 12.

off” near the lower floor line where the base board may butt against it. This string is, of course, a wall string, and is housed to receive ends of treads and risers. The manner of housing is shown at Fig. 12,

where the treads t and the risers r are shown in position and secured in place by means of wedges, x , y , which should be well covered with good glue before being inserted. Sometimes treads are formed with

two tenons at each end which fit into mortises cut in the strings. This, however, is only applicable with closed strings.

At Fig. 13, I show a housed string between newels. Here

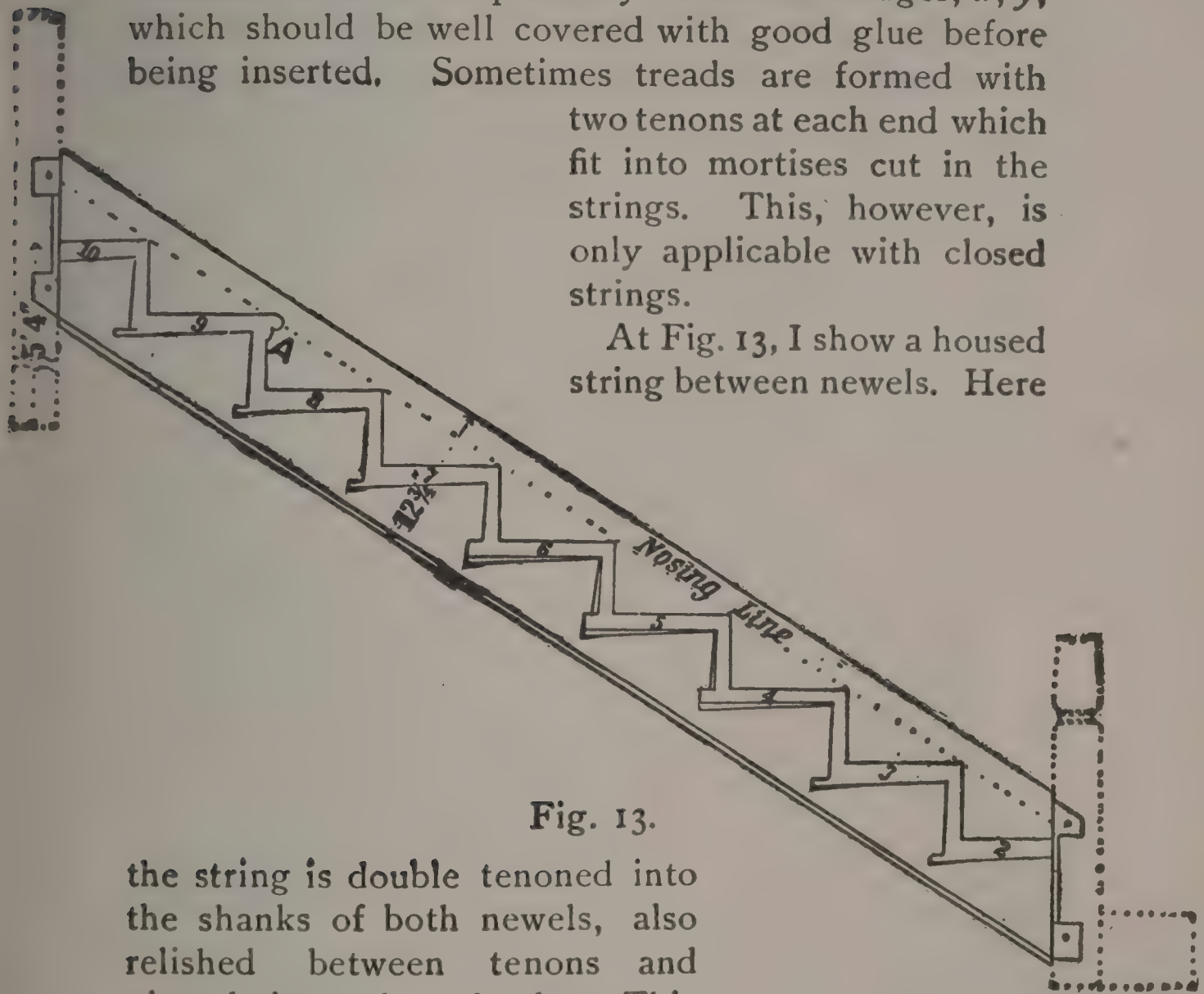


Fig. 13.

the string is double tenoned into the shanks of both newels, also relished between tenons and pinned into the shank. This string is made $12\frac{3}{4}$ in. wide, which is a very good width for a string of this kind, and the thickness should not be less than $1\frac{1}{2}$ in. The upper newel is made 5' 4" long from drop to top of turned cap. These two strings are intended to be capped with a sub-rail on to which the balusters are cut or mortised in. Generally a groove the width of the square of the baluster is worked on the top of these sub-rails, and the baluster is cut to fit in this groove, then pieces of

stuff made the width of the groove, and a little thicker than the groove is deep, are cut to fit in snugly between the squares of the baluster. This makes a solid job, and the pieces between the balusters may be made of any shape on the top, either beveled, rounded or moulded, in which case much is added to the appearance of the stairs.

Two methods of arranging strings and carriages and adjusting ends against trimmers are shown at Figs. 14 and 15. The section shown at Fig. 15 exhibits a method of strengthening the stair with simple uncut strings placed against the angles of the treads and

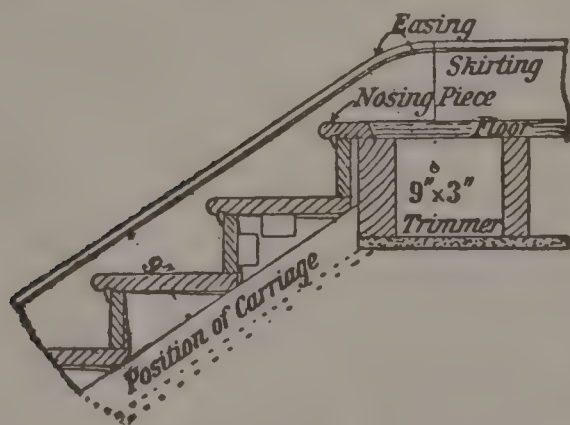


Fig. 14.

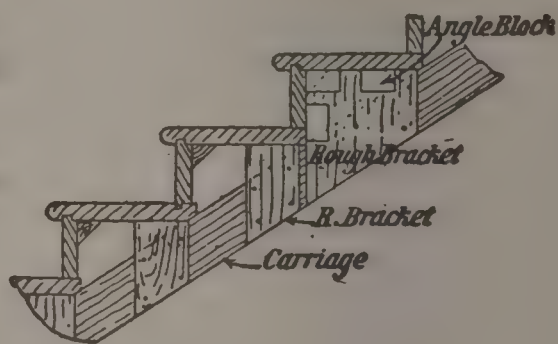


Fig. 15.

risers on the underside, and having pieces of rough boards—ends up—nailed to the rough carriage pieces and made to fit snugly against the underside of the tread and the inside of the riser. This method is not a commendable one, though much employed, as the nails may get loosened by the continual jar that a flight of stairs is subject to—a solid carriage piece is much better for the purpose.

At Fig. 16, I show an example of a cut and mitered string, with a portion of a tread, the end of which is mitered for return nosing, and dovetailed to receive ends of balusters. The other steps show how the

string is made and mitered to receive the riser and the tread. In the angle at the bottom tread and risers, an angular block, *a*, is shown. This tends to give firmness to the structure. The block is glued, bradded, or screwed, in place. A portion of a string, partly finished, is shown at Fig. 17. On this string I show brackets which are about $\frac{5}{16}$ of an inch thick, and

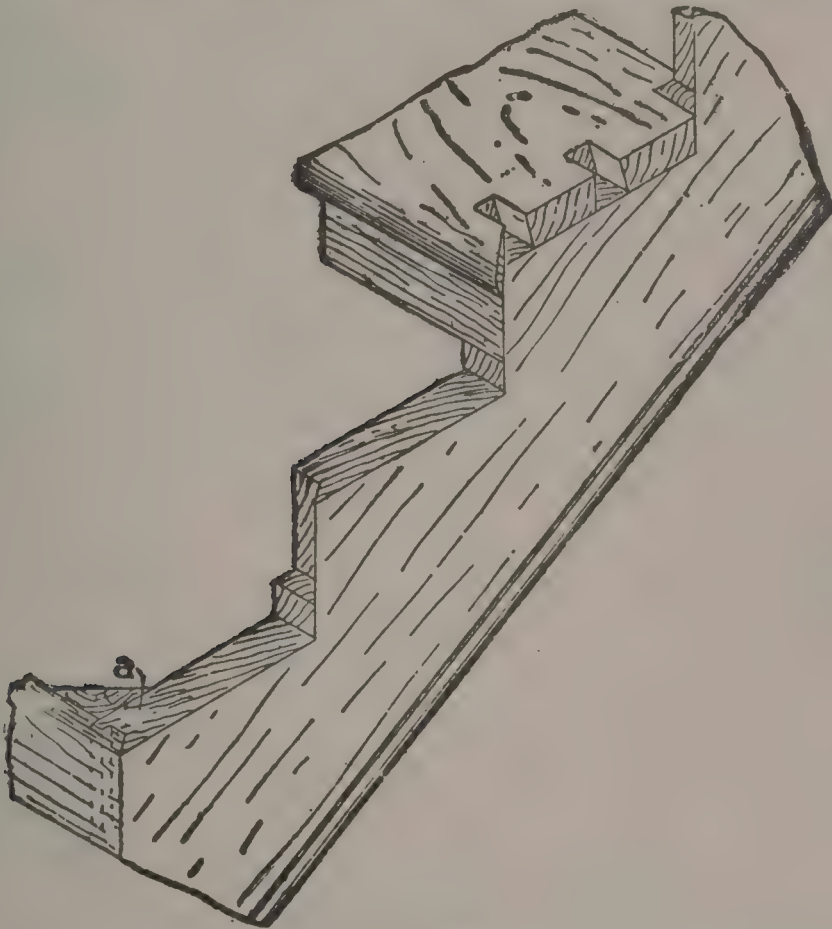


Fig. 16.

which are planted on the string. The brackets miter with the ends of the risers, and the ends of them which abut the miters should be the same length that the riser is wide, as shown at *b*. The treads must be left long enough to reach over the edge of the brackets; and the nosings and coves must also be long enough to cover the brackets as shown at *c* and *b*. The projection of the mitered riser is shown at *a*.

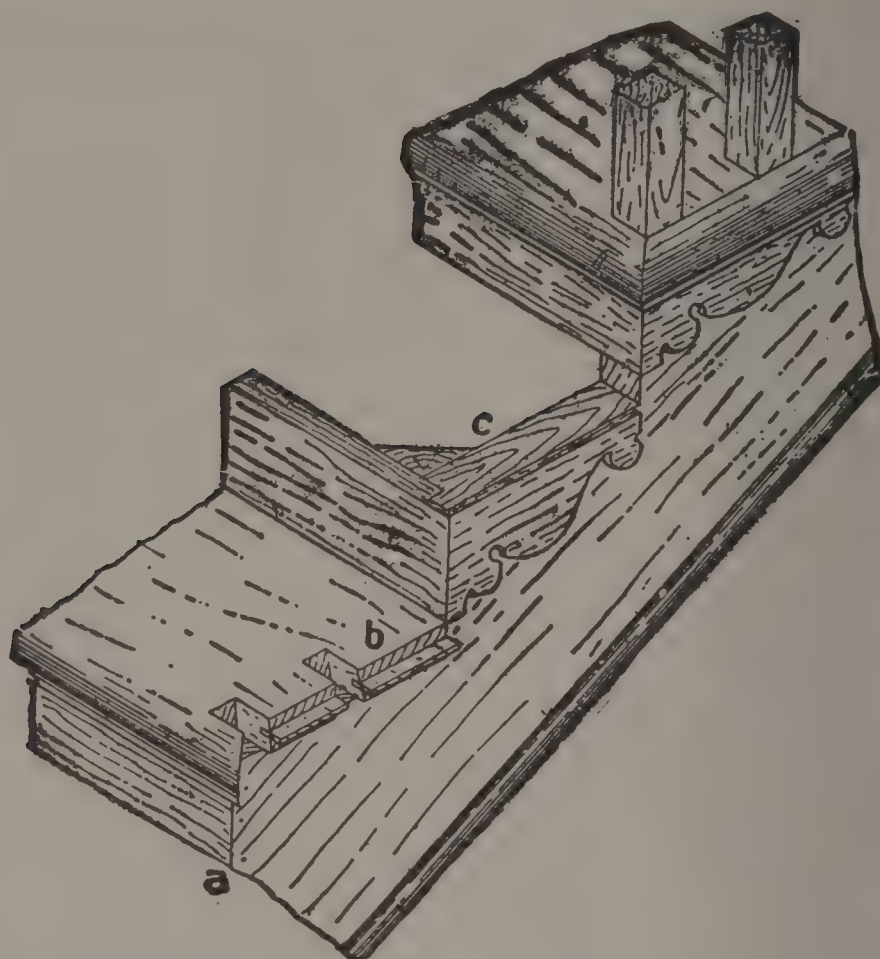


Fig. 17.

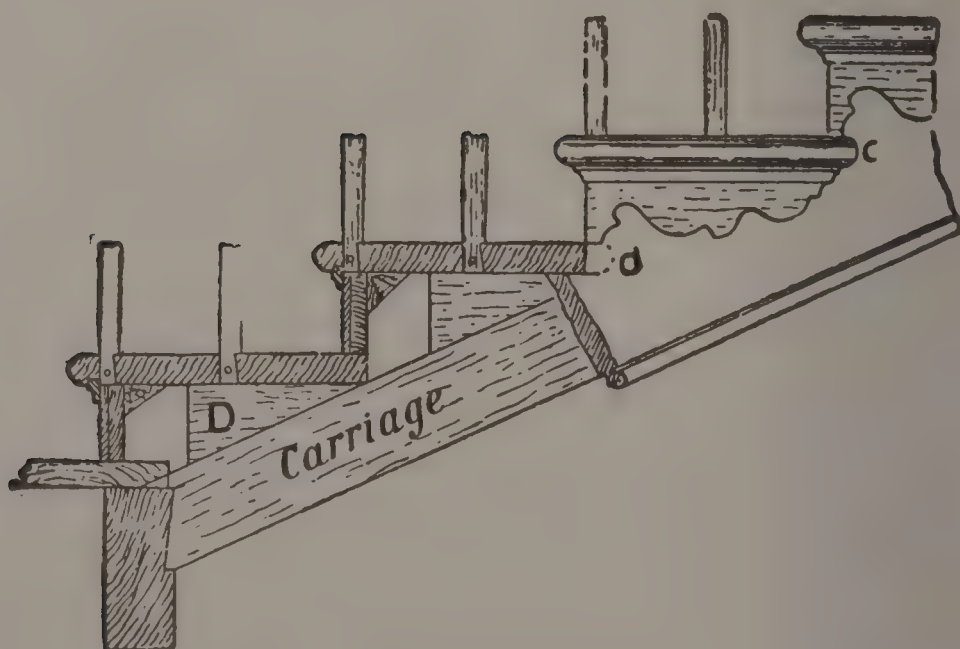


Fig. 18.

An end portion of a cut and mitered string, with a part of string removed, is shown at Fig. 18 in order to give an idea of the method of construction. O and C show the returned nosings, and the manner in which

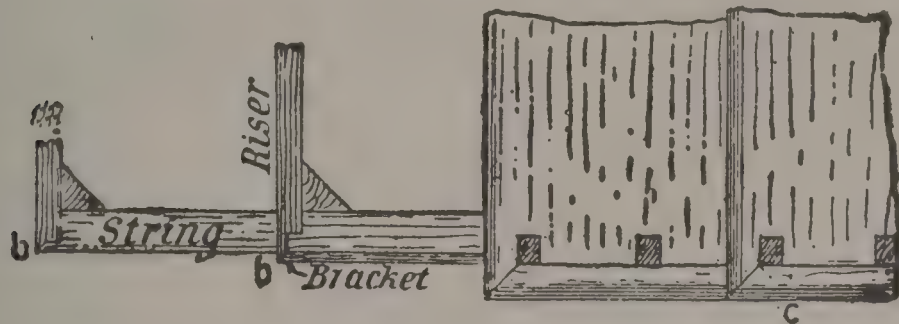


Fig. 19.

the bracket terminates on the nosing; D shows a rough bracket nailed on a rough carriage piece which is a device intended to take the place of a solid cut carriage string. The balusters are shown as being dovetailed into ends of treads.

The illustration show at Fig. 19 is simply a plan of Fig. 18, and shows the position of the string, bracket, riser and tread. The manner of mitering the riser, string and bracket is shown at *b*, and C shows the miter of the nosing at the angle of the step.

The return nosings should be fastened to the tread either by dowels or by a feather or slip tongue. The

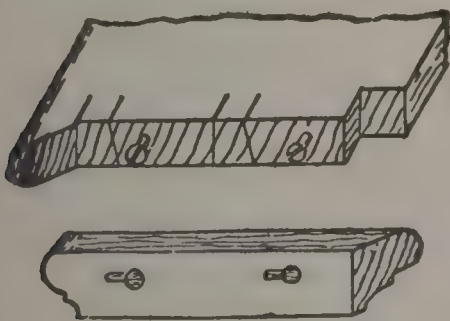


Fig. 20.

manner of doweling the nosing is shown at Fig. 20. Slot screwing may be employed for this purpose, particularly if the treads are hardwood and the work is to be polished. These screws are first screwed solid into the nosing—that end of the bolt being cut like an ordinary wood screw—and a pocket or pockets are

cut in on the underside of the tread, to receive a nut, which is used to tighten up the joint when the nosing is put in place, just as the butts of handrails are fastened together. The nosing shown at Fig. 21 is fastened

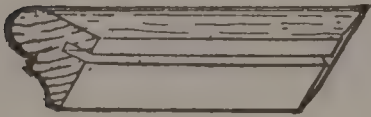


Fig. 21.

to the end of the tread by aid of a tongue or feather which is glued into a groove made in the end of the tread and left to project the proper distance. The nosing is

also grooved, as shown in Fig. 21, and which corresponds with the groove in the tread; the feather is glued, after which the nosing is driven in place while the glue is warm. Many workmen put in these feathers with the grain of the wood "on end," that is, with the grain in the feather at right angles to the grain in the nosing. This, I think, makes the better job. On cheap stairs the nosing is simply nailed on, the heads of the nails "set" and the nailholes afterward puttied up.

A very good method, though rather costly, of connecting tread, riser and cove, is shown at Fig. 22,

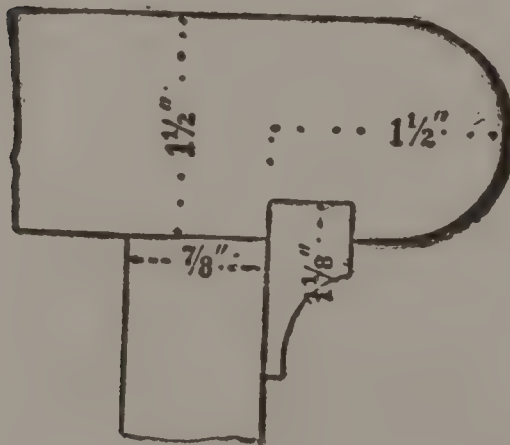


Fig. 22.

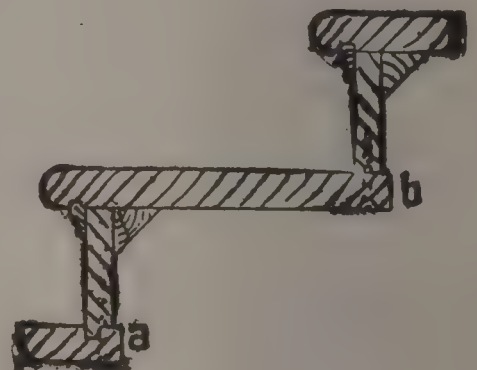


Fig. 23

where the cove is glued into a groove made in the tread. When the work is put together the cove is braded to the riser, which ties the tread down solid to

the riser. The completed work is shown at Fig. 23, the lower tread *a* having the riser tenoned into the tread. At *b* the tread is screwed from below to the edge of the riser. This makes strong work. The usual

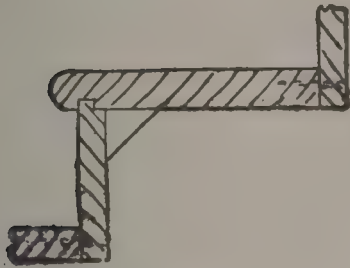


Fig. 24.

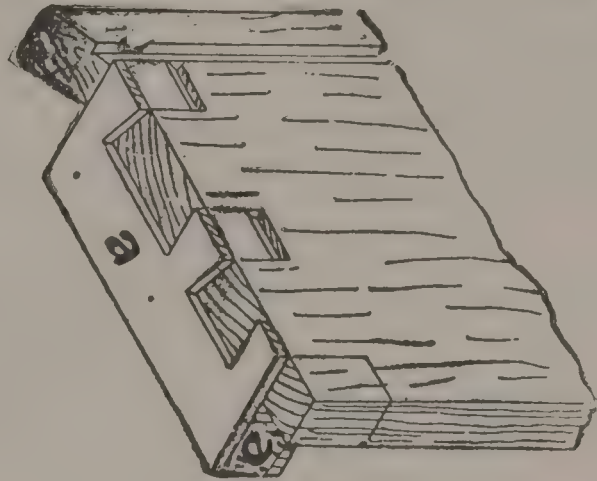


Fig. 25.

method of building a step is shown at Fig. 24. Here the riser is tongued into the tread above and runs down below the lower tread, but fits close to its edge to which it is nailed as shown in the upper portion.

At Fig. 25, I show a quick method of marking the ends of the treads for the dovetails for balusters. The

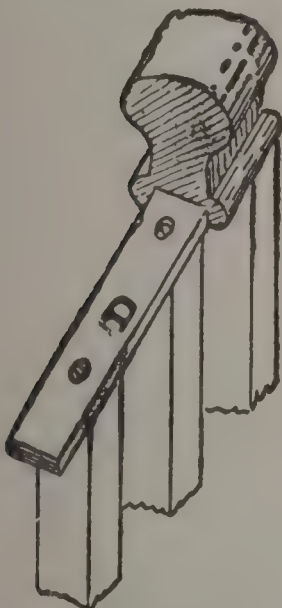


Fig. 26.

templet marked *a* is made of some thin stuff, preferably zinc or hardwood. The dovetails are marked out as shown, and the intervening spaces are cut out, showing the dovetail portions solid. The templete is then nailed or screwed to a gauge block, *e*, when the whole is ready for use. The method of using is shown in the illustration.

At Fig. 26, I show an exceedingly good method of fixing balusters before the rail is put on. A thin bar of iron, *D*, is spaced off and drilled, with the

small hold over the center of the baluster. Screws or nails are then driven into the baluster as shown, through the holes in the iron. The rail is grooved to suit the thickness of the iron bar and laid on as shown. Holes should be drilled here and there between the balusters, and screws put through them into the wooden rail, which makes the whole work very solid. The iron bar should just be the width of the balusters, and the groove in the wooden rail should be deep enough to admit of the whole thickness of the metal.

Often the bottom tread of a stair takes a quarter turn and finishes against the base of the newel post. When this happens, some special work on the riser, tread, and nosing is sure to be required. Fig. 27 shows how the difficulty is dealt with. The riser is left the

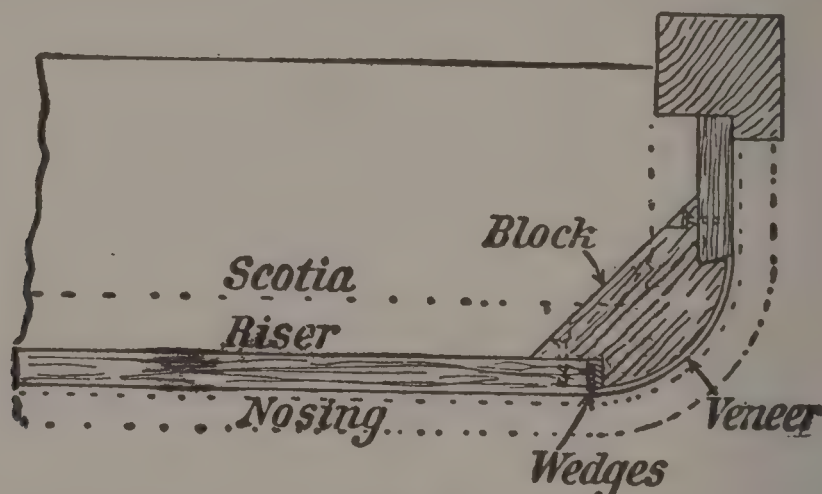


Fig. 27.

whole length of curve and return, but is cut out where the curve occurs and thinned down to a quarter of an inch. A solid block, as shown, is fastened to the floor in the proper place, being curved to the right shape. The newel is put in position, but is rebated out the depth of the riser, as shown. The thin portion of the riser is then steamed, glue is put on the block, and on

the thin portion of the riser that sits against the block, and when all is ready the short end of the riser is forced in the rebate shown in the newel, and is gently bent around the block as will be seen. If the work is done well, the job will be complete and satisfactory. Some workmen have concave cauls, or pieces of wood, cut

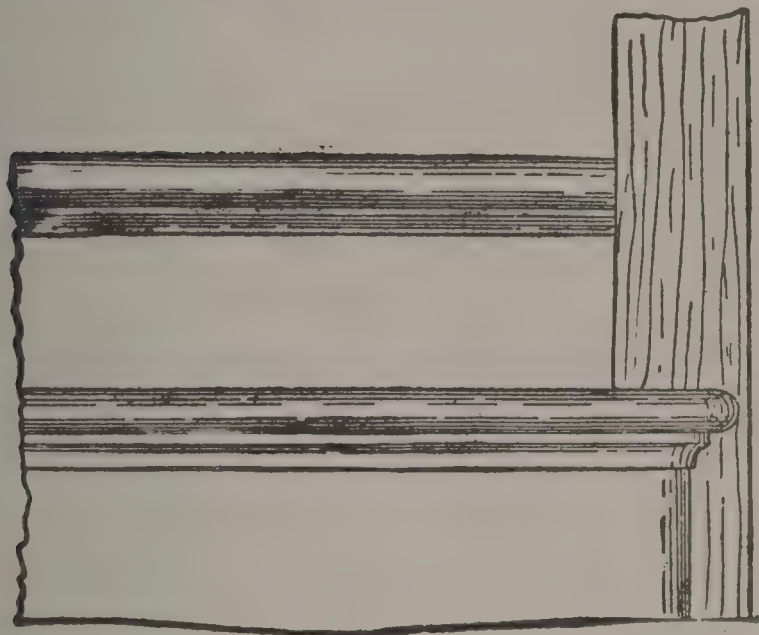


Fig. 28.

out to place against the face of the work and wedge them tight against the curved riser, by any device that might suggest itself.

An elevation of the finished step is shown at Fig. 28,

where the rounded tread and riser are seen returned against the newel post base.

The plan of a portion of stair, as shown at Fig. 29, is given at Fig. 30. Here is seen the ends of the treads as mitered, the letters WS indicate

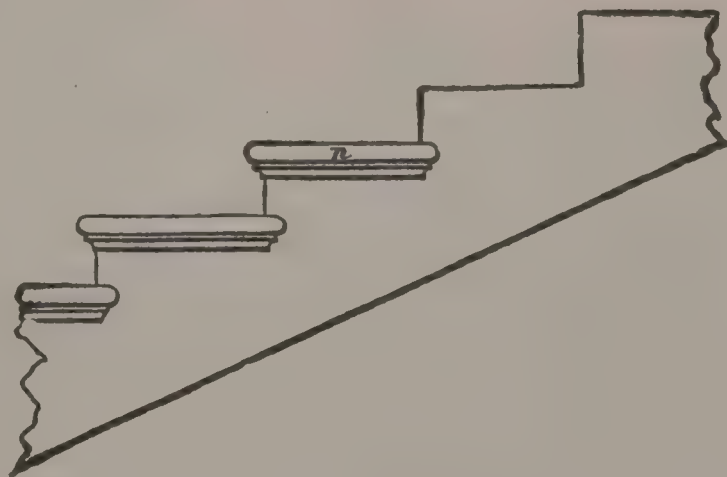


Fig. 29.

the wall string, RS the rough string, and OS the outside string. The miters of the risers are shown at *aa*,

which gives the miters as being cut against the string. The square spots shown at B, B, B, B, are the



Fig. 30.

dovetail mortises for ends of the balusters. Fig. 29 simply shows the string receiving the treads and return nosings.

The illustration shown at Fig. 31 represents a portion of a flight of stairs, having cut strings, S, S, on each side. The tread is shown at *t* and the riser at *p*. These are a cheap kind of stair and are nailed together. This class of stair is generally intended to fit in between walls or partitions, the strings being spiked to studding or to board timbers or

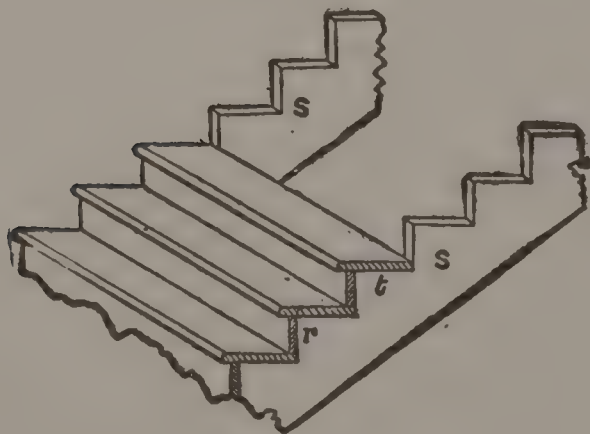


Fig. 31.

wood bricks, as the case may be.

HOW TO DETERMINE THE RISE AND GOING OF A
FLIGHT OF STAIRS

I have taken the following from Ellis' *Practical Treatise on Joiner's Work*, because it seems to me to be about the best thing written on the subject, at least, the best I have come across. "The amount of going and rise given depends chiefly upon the amount of floor space allotted to them, and upon the height of the story; but subject to these restrictions, there is room for considerable variation. To obtain a stair that shall not be fatiguing or awkward to ascend or descend, the going should bear a certain ratio to the rise. Various methods have been proposed by writers on the subject to obtain the ratio, of which the following are the best known and most practiced:

"1. It is assumed that the average length of step in walking on the level is 24 in., and that it is twice as difficult or fatiguing to climb upward as it is to walk forward. From these premises it is deduced that one going one step forward, plus two rises or steps upward, should equal 24 in., which put in the form of a rule becomes,

"To Find the Rise When the Going Is Known.—Subtract the given going from 24 in., and divide the remainder by 2 for the rise.

"To Find the Going When the Rise Is Known.—Multiply the given rise by 2, and subtract the product from 24. The remainder is the proportionate going required.

"2. The product of the going and rise multiplied together is to equal 66. Example: Going 11 in. $\times$ 6 in. = 66, and 7 in. rise $\times$ $9\frac{3}{4}$ in. = 66. Rule by this method: Divide 66 by the given rise or going to ascertain the proportionate going or rise.

"3. Assume 12 in. going and $5\frac{1}{2}$ in. rise as a standard ratio. To find any other, for each addition of $\frac{1}{2}$ in. to the rise, subtract 1 in. from the going. Example: Rise 6 in., going 11 in.; rise 7 in., going 9 in. It will be noted that by this method the sum of 2 rises plus the going equals 23, which affords an easier stair than the first-mentioned method.

"When the total rise of the stair is known, as shown by the story rod, Fig. 32, and the approximate rise of

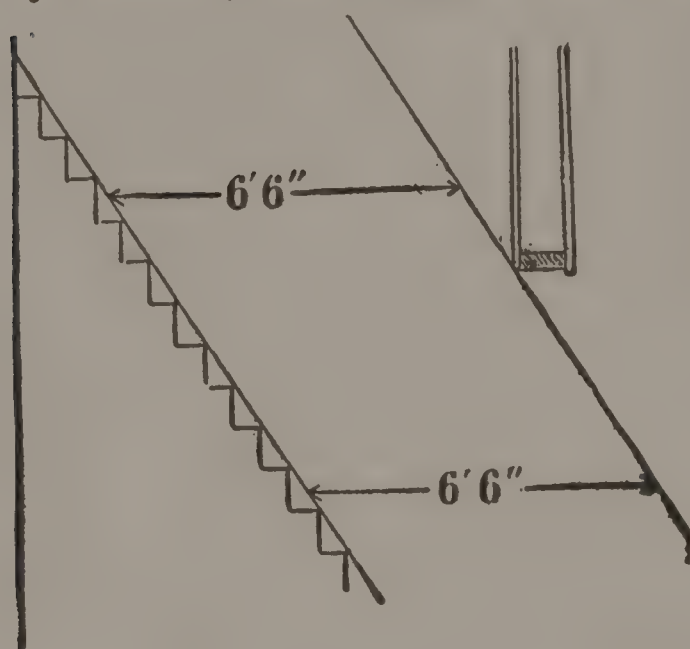


Fig. 32.

the step is given, the exact rise is obtained by calculation, thus: Reduce the total height to inches, and divide it by the desired rise. If there is no remainder, the divisor will be exact rise, and the quotient will be the number of risers

required. If there is a remainder, again divide the sum by the quotient, discarding the fraction, and the result will be the exact rise. For instance, let the height of the story be 10 ft. 6 in., and the proposed riser $6\frac{1}{2}$ in. $10 \text{ ft. } 6 \text{ in.} = 126 \text{ in.} \div 6\frac{1}{2} \text{ in.} = 19 \text{ with } 5 \text{ remainder; then } 126 \text{ in.} \div 19 = 6\frac{5}{8} \text{ in. full as the rise, and the proper ratio of going to this, as found by the first method, is } 6\frac{5}{8} \times 2 = 13\frac{1}{4} - 24 = 10\frac{3}{4}$; but the exact going is found by dividing the plan into 18 equal parts, as there is always one less tread than the number of risers, in consequence of the landing acting as tread

for the last riser. No arbitrary rule can be given for the treatment of the plan, which must be subject to circumstances. Every attempt should be made, however, to dispense with winders, which should be introduced in case of necessity, when they are better placed at the top of a flight than at the bottom."

All stairs should be so devised that not less than 6 ft. 6 in., head-room between tread and trimmer, is given, but, as shown in Fig. 32, it is much better to give this much space from the going line to the trimmer, then

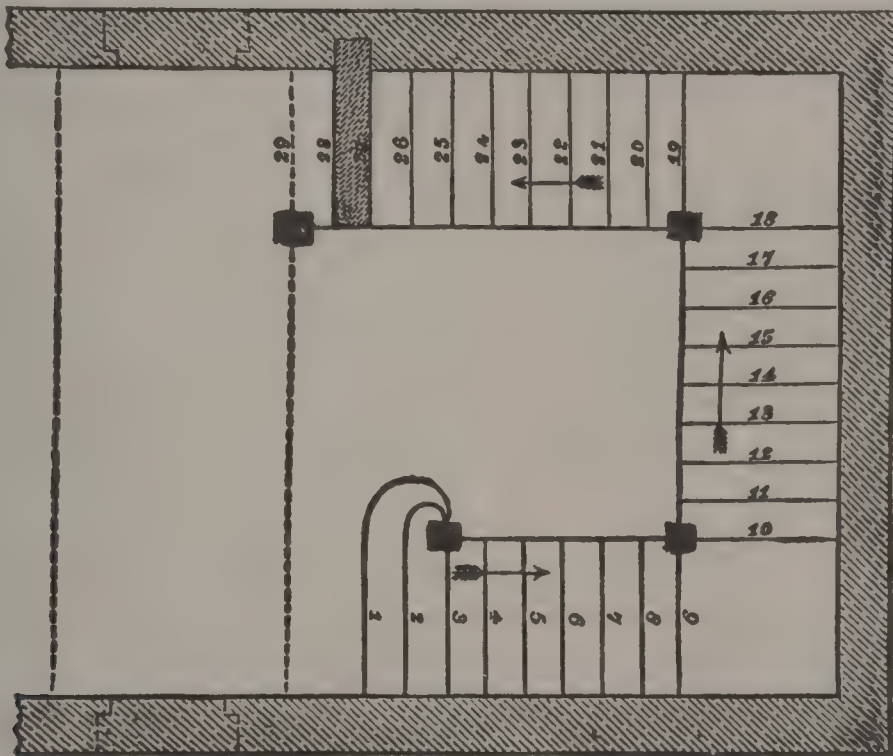


Fig. 33.

there will be no danger of a tall man striking the trimmer with his hat on his head. There will be cases, of course, where to give so much space for head-room will be impossible, but in ordinary stairways any less space than that determined will surely prove unsatisfactory.

VARIOUS PLANS FOR STAIRS

A newel or landing stair can be devised that it will serve the purpose for almost any possible contingency;

and in order to make this plain I show a number of plans, which I am sure will prove of use to the general workman as well as to the stair-builder, as they offer hints and suggestions for dealing with almost every condition and situation that are likely to present themselves in preparing plans for stair runs which are intended to be of the platform style.

In Fig. 33, I showed a plan of a stair having two landings, and a circular-ended step, with dotted lines showing trimmer timbers. At Fig. 34, I show another plan with the order of going reversed, and with the flight between the landings having a less number of

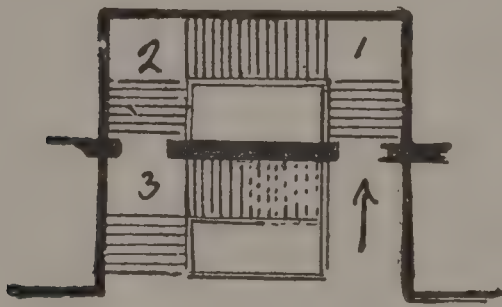


Fig. 34.

steps. Fig. 34 only shows five risers, while Fig. 33 shows nine risers. The latter example also shows the two lower steps rounded off to fit against the newel post. The flight shown in Fig. 34 is supposed to be built in between studded partitions

while the stairs shown in Fig. 33 are built in between brick walls.

Fig. 34 shows a plan of stair in the Time St. Depot, Liverpool, England. This is rather a peculiar stairway, as from the third landing the stair starts off in two directions so as to reach different parts of the building more conveniently. The plan shown at Fig. 35 illustrates an elaborate entrance and stairway to the National Gallery of Arts, London. This is a peculiar stairway inasmuch as there are two flights leading up to a large platform where the upper flights broaden out and carry the visitor to the upper floor either to the right or to the left. This is rather an

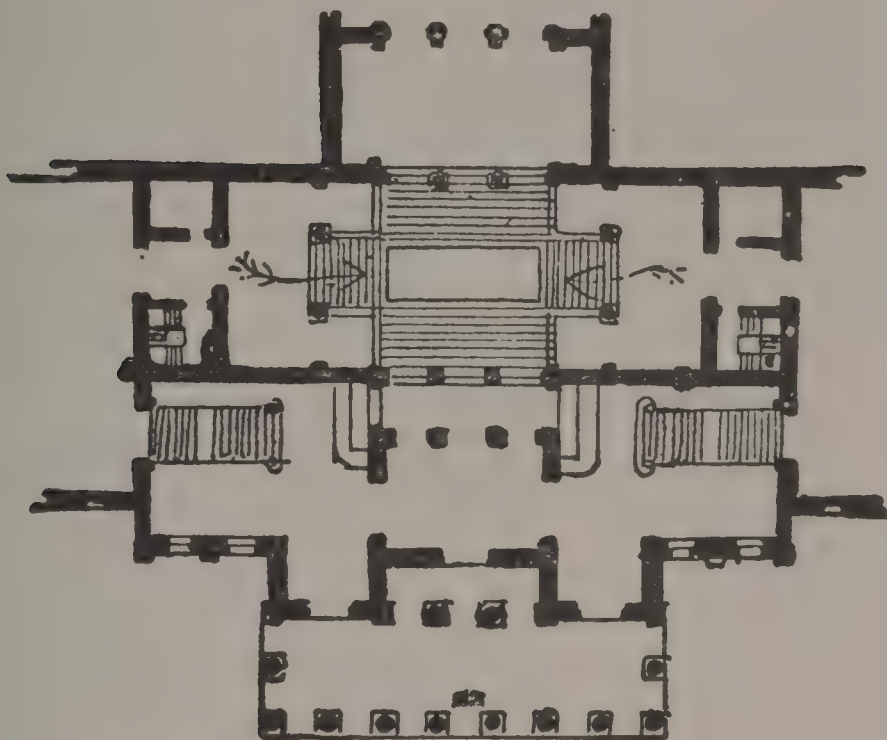


Fig. 35.

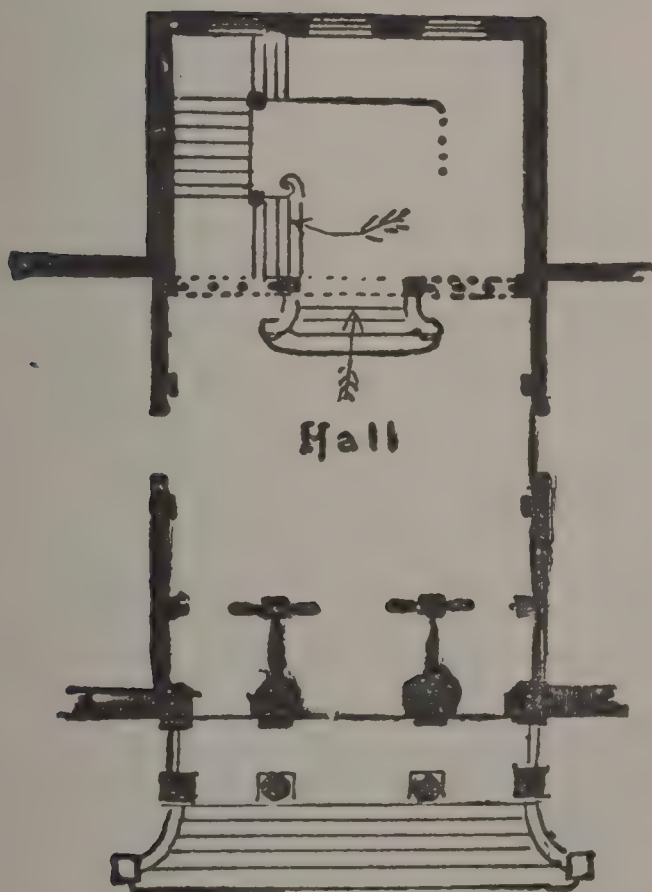


Fig. 36.

ingenious arrangement and might be made use of in many instances for public buildings.

An effective arrangement for a hall stair is shown at Fig. 36, where a short flight of stairs lead to a raised dais from which a second flight of stair springs, in which there are two landings. The rail over the lower flight runs from two starting newels, and fin-

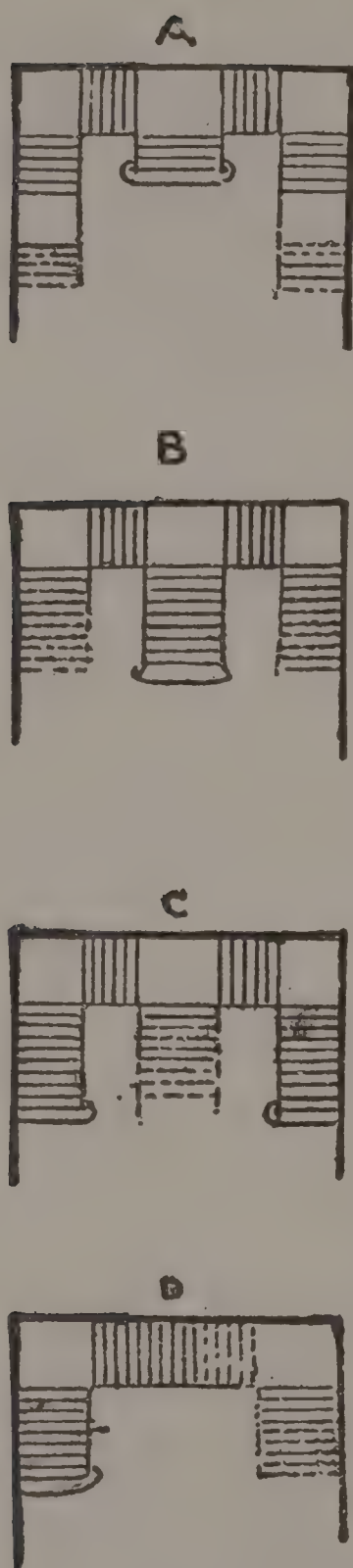


Fig. 37.

ishes against columns having their base on the plinth of the dais. The windows in the rear of the hall are filled with art glass, and the whole is artistic and impressive.

A series of sketches for plans is shown at Fig. 37. A shows a stair with five landings, the first step being situated in the center. B exhibits a similar stair with three landings. C shows a stair with three landings and two starting flights leading to a wider flight above. D shows a flight with two landings and having but one starting point. This is a common kind of stair and much in vogue, but lacks architectural effect; either of the plans shown at A, B, C, is preferable from an artistic point of view than the plan shown at D.

Another series of plans is shown at Fig. 38, which show the relation of the stair to other portions of the house. No. 1 shows an ordinary flight with landing at the top. No. 2 shows a flight having two landings. This is an artistic flight and is always effective. No. 3 is something like No. 2, only reversed, and is lighted by a window on the top landing. This also, makes a very effective stair for a middle class dwelling, and always looks well if finished in hardwood.

Another series of plans is shown at Fig. 39, with parts of the plans of the buildings along with them. No. 1 shows a stair with two landings and a "step-off," on the second landing at O, leading to rooms over the kitchen which are used for the domestics. No. 2 shows a very different arrangement, the stairs being built in an inner hall which leads into a conservatory. The plan shown at No. 3 is very much in vogue at the present time, and is really a very good style of stair.

A very good "lay-out" for a hall and stairway is shown at Fig. 40. Entrance to dining-room, drawing-

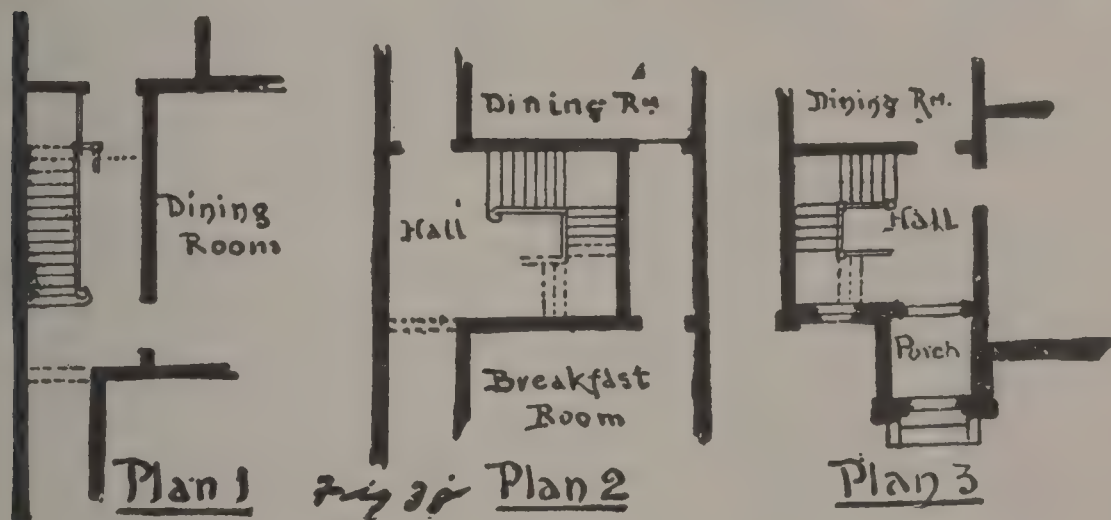


Fig. 38.

room and library is gained direct from the hall, and the hall is entered from the street by way of vestibule as shown. Access also to kitchen and outer offices, is also obtained from the hall. The stairs are well arranged with wide platform and is well lighted by two windows over the platform; the windows being filled with suitable art glass. This particular arrangement of hall, stairs and rooms is worthy of being thought over by those of my readers who may have anything to do with designing floor plans.

I think I have now given a sufficient number of plans

to enable the workman to "lay-off" a stairway that will "fit" in almost any situation, or at least to suggest to

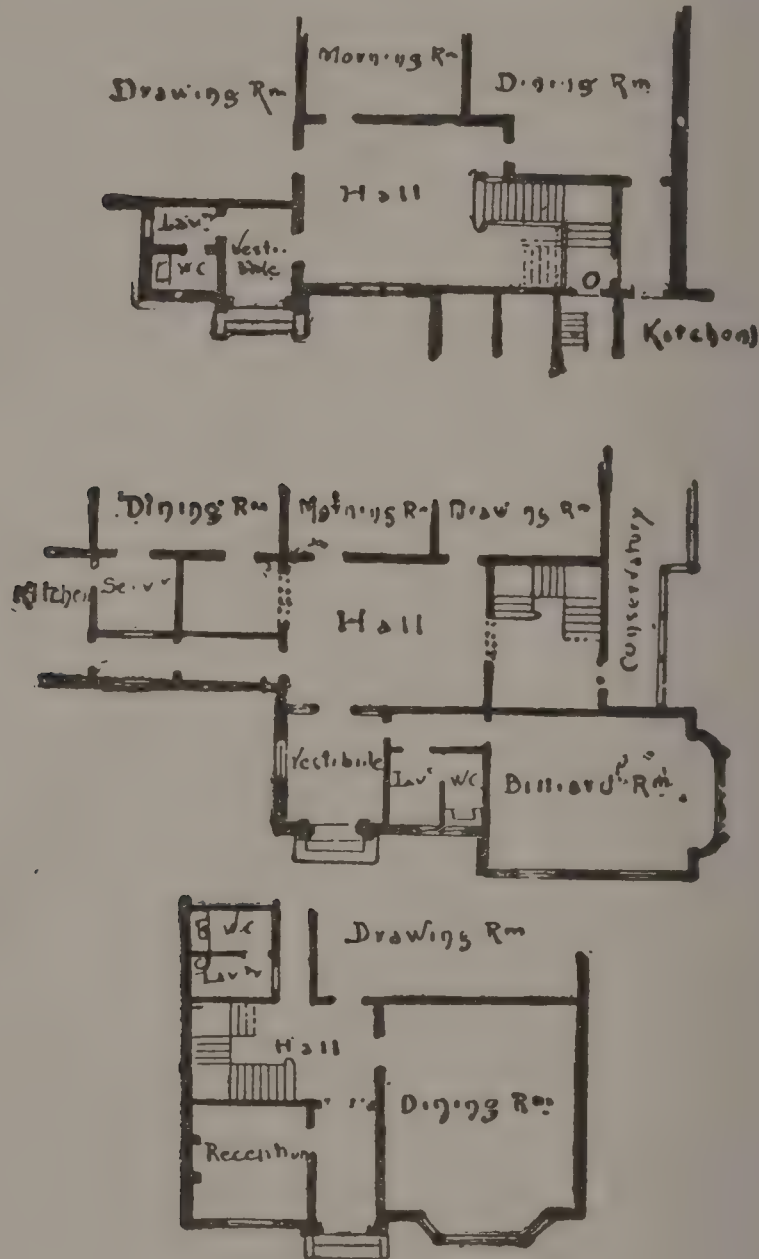


Fig. 39.

him how the difficulty may be worked out, so I will now leave this subject, feeling that I have done it full justice.

NEWELS, NEWEL POSTS, BALUSTERS, AND ORNAMENTAL BALUSTERS

The different styles of newels and newel posts are without number, and I will not make any attempt

to describe or illustrate more than will give the workman an idea of those most common in use at the present time, and a few elaborate ones now in existence that were designed and set up by old workmen.

The sketch shown at Fig. 41

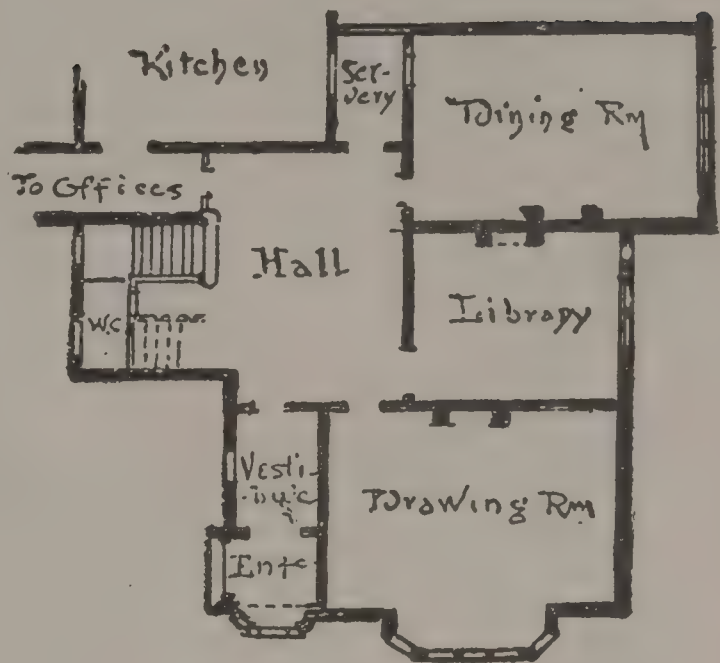


Fig. 40.

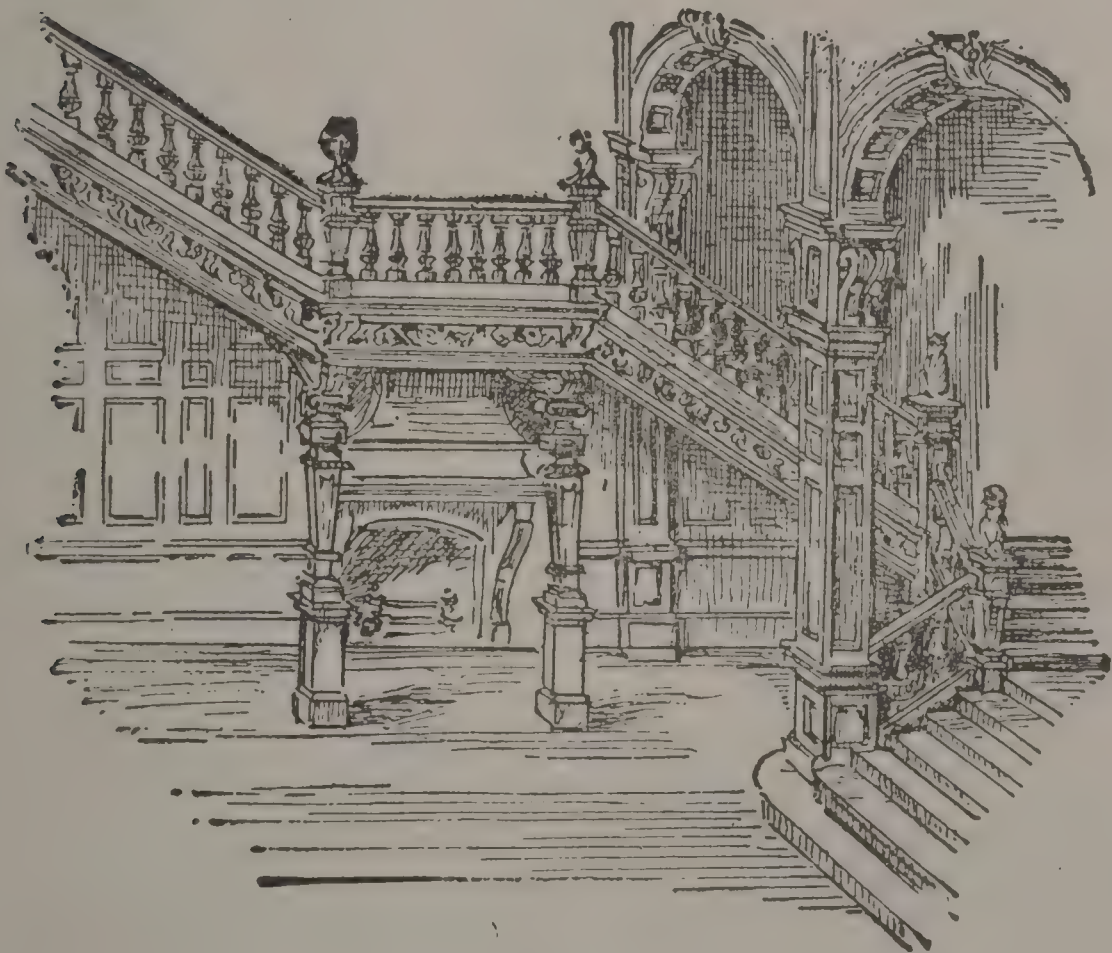


Fig. 41.

is a design for a large hall and stairway, and is in Mercer's Hall, London; the stair is supported on columns, and shows three landings with balusters and newels. It will be noticed the long flight is last, leading up to the floor. This seems to be a rule with English stairways, as it is argued that there is a longer

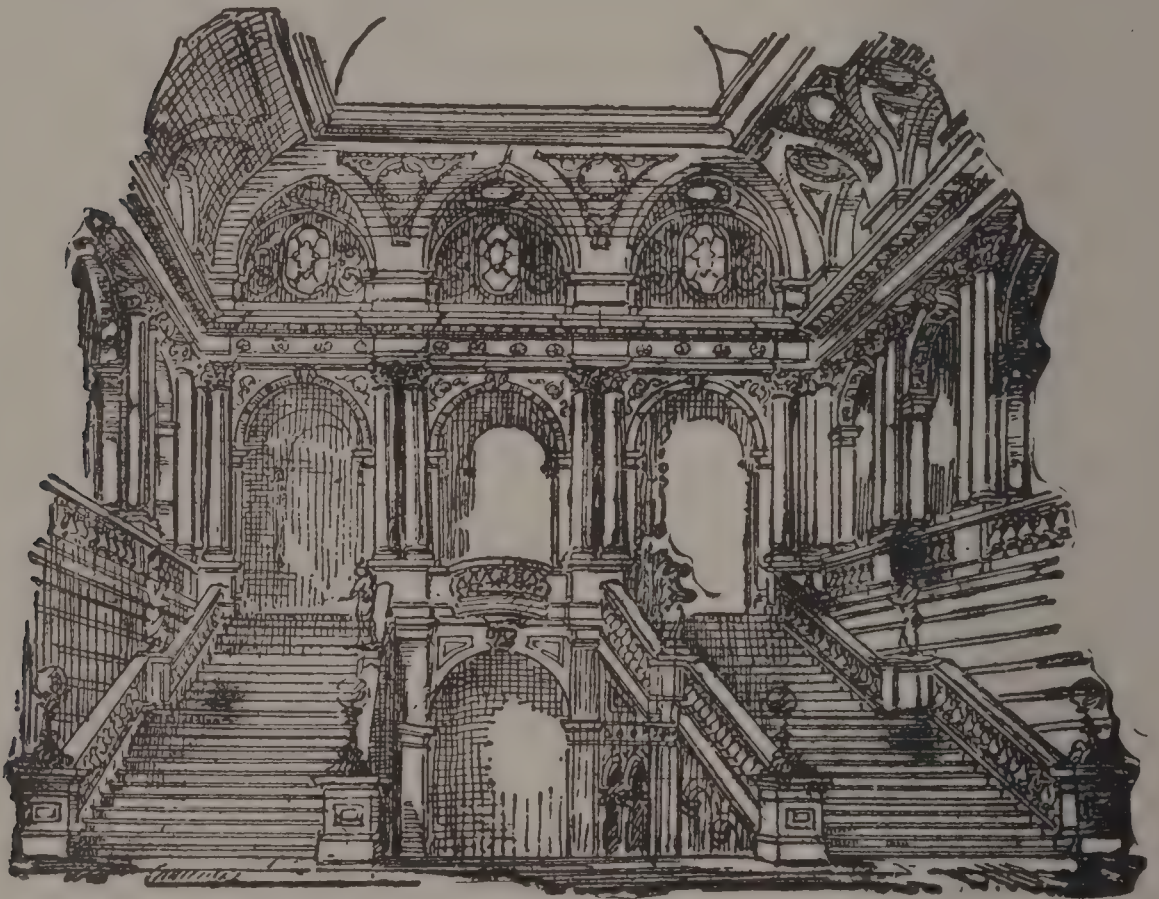


Fig. 42.

rest at the top, therefore the long rest comes after the long rise.

Another and still more elaborate staircase is shown at Fig. 42. This is a stately and palatial class of stairs and consists of central flights branching off into lateral flights, surrounded by a gallery separated by columns or arches. This shows the main stairway and hall of the opera house, Paris, France.

The two lateral flights lead to a spacious landing, from which a wide curvilinear-shaped flight of stairs ascends with wing stairs to the gallery. The elegant and graceful lines of this staircase make it almost unique among great modern examples. The architect has introduced the ramping arch below the flights, and by curving the balustrades outward has given ease of ascent and grace of outline. Round the gallery rise coupled columns of red polished granite with Ionic capitals carrying entablatures and arches, above which runs a rich truss cornice. Over the cornice on each side are rows of lunettes, surmounted by the fine vaulted quadrangular domical ceiling. Much of the grandeur of this staircase is due to the surrounding gallery, which impresses the visitor on ascending. The magnificence of the *escalier d'honneur* is heightened by the arrangement of the minor stair and the open loggia and vestibule. As a model of planning the Paris Opera House stands pre-eminent. It forms a long rectangle, flanked by projecting annexes, which give much variety to its length. There are three parts or divisions symmetrically disposed to the major and minor axes: the stage occupying the whole breadth of the building; the theater proper, or auditorium, forming the center of the building, and including the grand staircase; and, lastly, the promenade and open loggia in front. The staircase hall forms a square and complete structure between the foyer or promenade and auditorium, and is surrounded by corridors. The plan of this building is an instance of the centralizing mind of the French; every organic function is expressed in the structure. In a large public building the staircase performs an essentially distinct and public function, and too much prominence cannot be bestowed upon it.

The newels and panel-carved balustrade shown at Fig. 43 exhibits an extremely rich example of sixteenth century work. All this is taken from work still standing in a house at Greenwich, England.

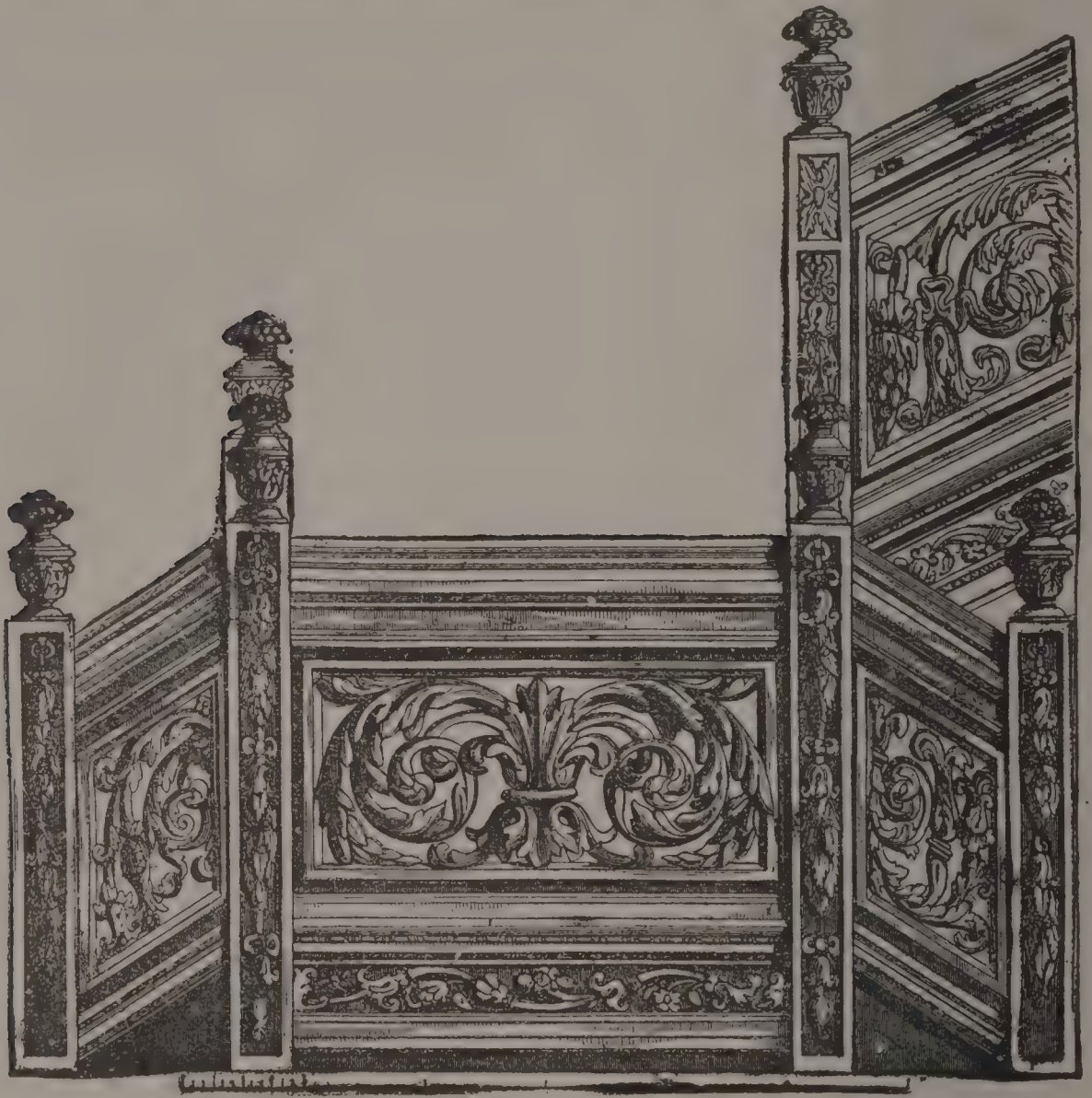


Fig. 43.

The interior of the house is very nearly in its original state. There is a very curious internal court. The rooms have several good door-cases and ornamental plaster ceilings.

Fig. 44 is a plan of the stairs, showing the double

approach. The sketch, Fig. 45, shows the half section of handrail. Fig. 46 shows section of the entablature under steps with the carved pendant under newel; and Fig. 47 shows the top of one of the newels at large.

Stairs finished in this manner are coming into vogue again, and a number of similar ones have been built in our larger cities where cost was only a secondary consideration. Stairs of this kind, to be effective, should be massive in appearance; the newels should be heavy and the carving done in the solid. The newels in the

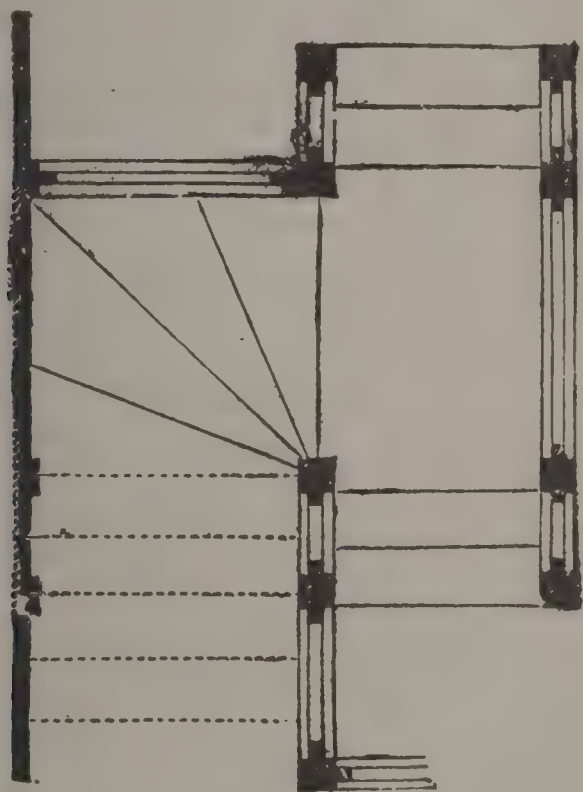


Fig. 44.

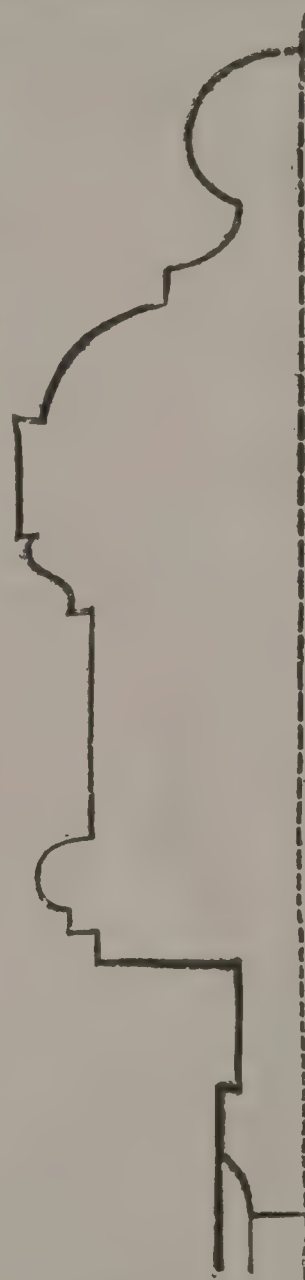


Fig. 45.

example shown, are rather light in appearance, but the whole mass is quite impressive. The details, Figs. 45, 46 and 47, are left to a larger scale than the main illustration so that the workman may the easier enlarge and copy them for actual work, if he so desires.

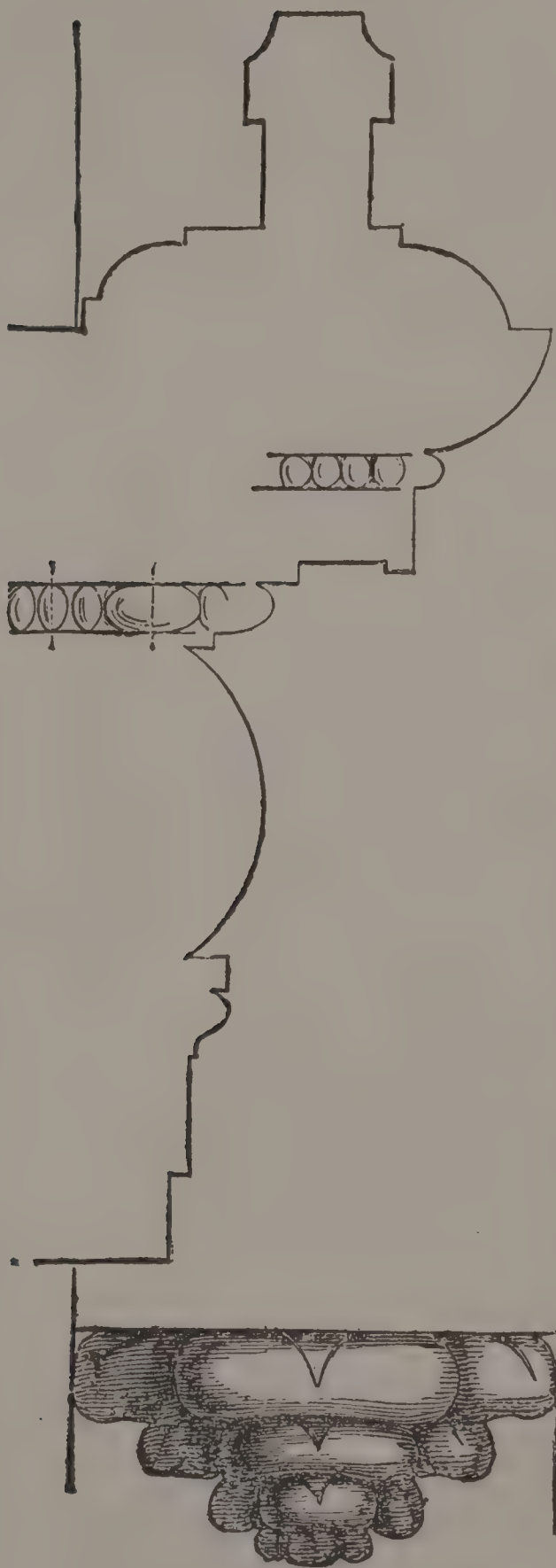


Fig. 46.



Fig. 47.

A flight of stairs with newels, having carved balustrade, strings and newels, is shown at Fig. 48. This is a

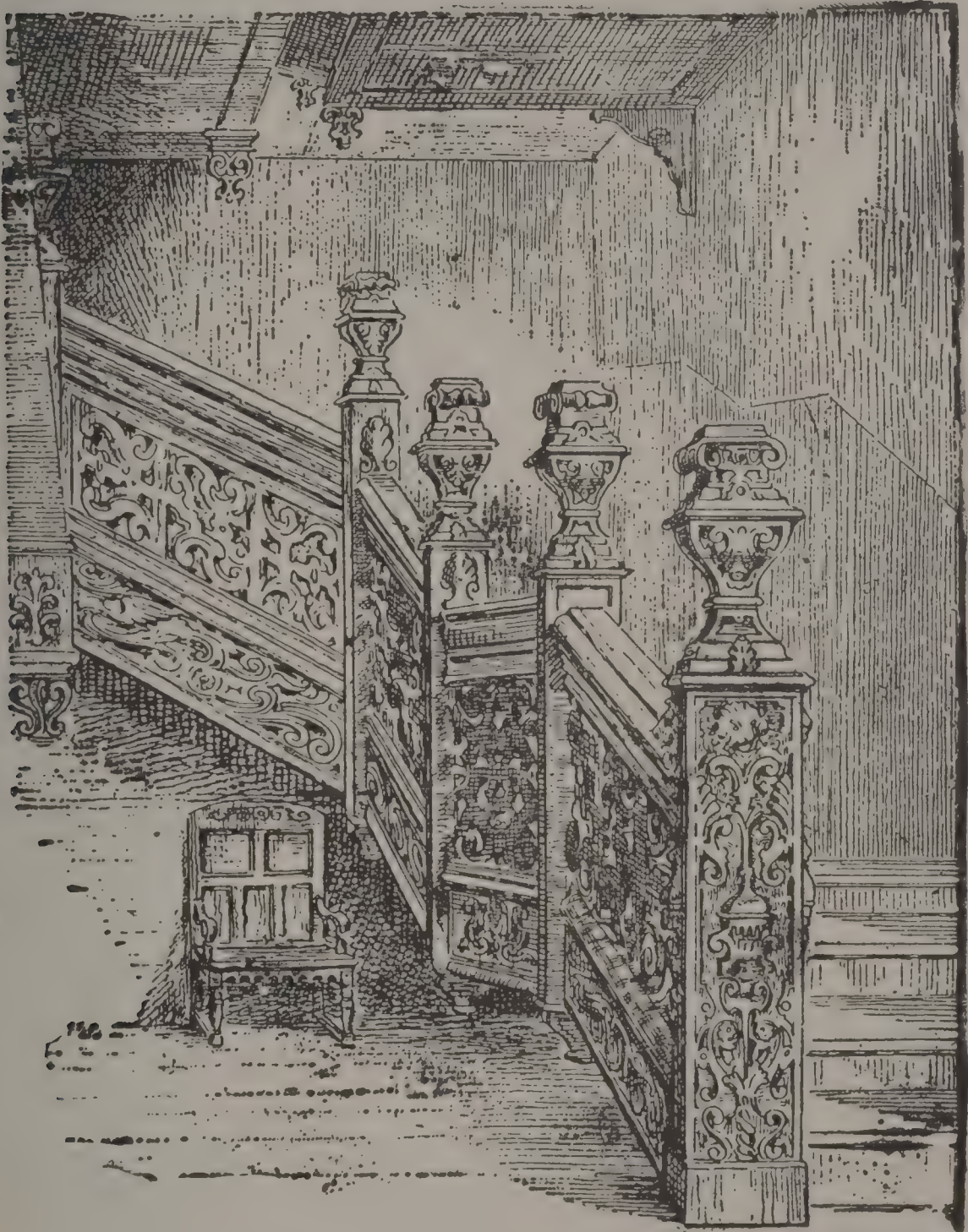


Fig. 48.

French design, and has a very broad rail elaborately wrought. The carved string is a special feature of this

example, so also are the square carved vases that surmount the newels. It will be noticed that the newels in this example are much larger in section than those

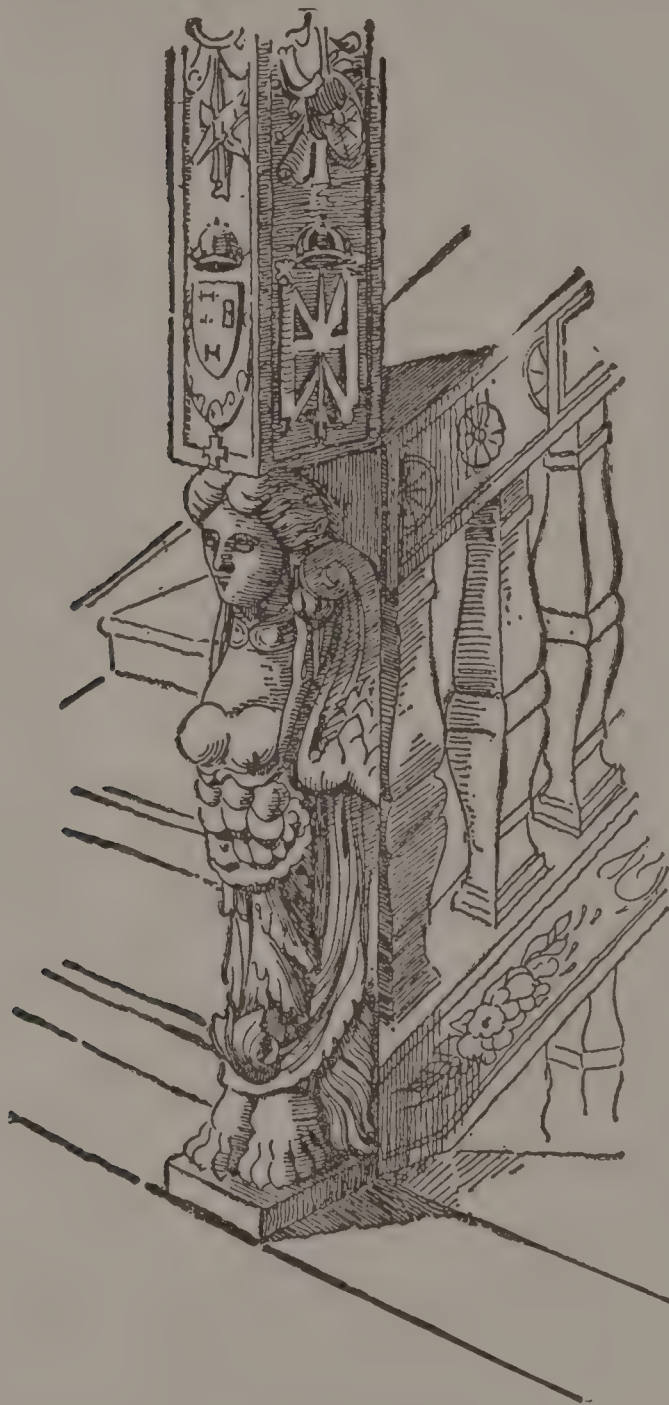


Fig. 49.

shown in Fig. 43. This is, I think, a gain in appearance. It will be noticed that the central ornament on the finished faces of the newels is partly turned and partly carved, so must necessarily be planted on, as are perhaps the other carvings.

A curious example of a newel post is shown at Fig. 49, which represents a portion of a stairway in the Hotel Cluny, Paris, France. The stair has a close heavy rectangular string with carved rosettes sunk flush on both sides. The balusters are square in section and are massive, with all the

mouldings worked on the rake of the stairs on two sides, and square across on the upper and lower sides. This style of baluster is quite common in Europe and

is really quite effective. Another peculiarity of this

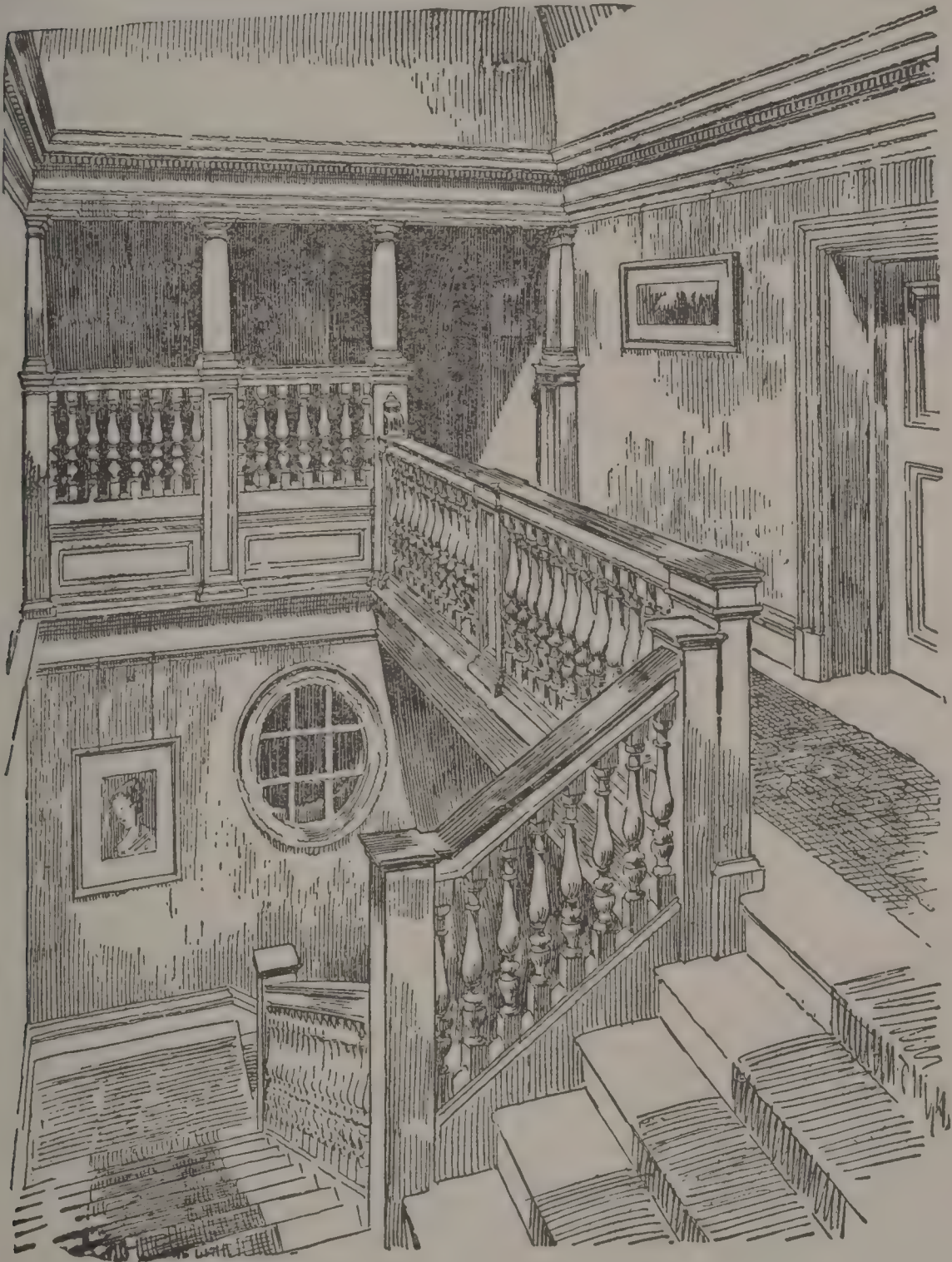


Fig. 50.

stair is the upper portion of the newel which runs up to the ceiling, and is carved on its four faces with

various emblematical devices. This gives the whole work rather an odd appearance.

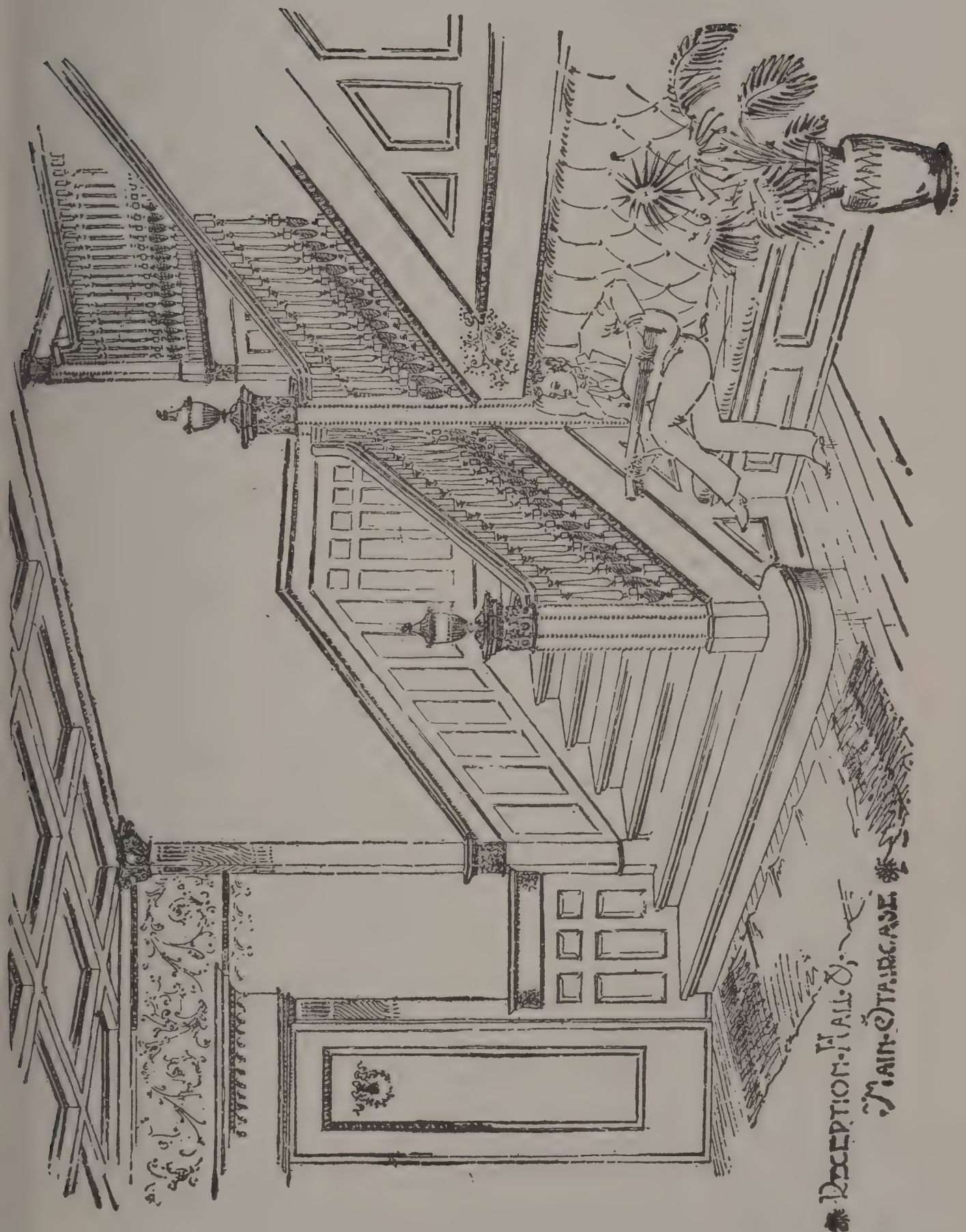
A modern stairway with landings is shown at Fig. 50. This is in Colonial style and has a very cozy and inviting appearance. This example is taken from a New England house, and is noted for the width of stairway and breadth of tread; the rise being little more than five inches. A peculiarity of this stairway is the twin newels at the main landing. This is a departure from the general practice, and is employed here for architectural effect. The newels are plain, yet they are quite effective. The balusters are heavy and placed pretty close together.

Another staircase of recent design and intended for a house in Philadelphia, Pa., is illustrated at Fig. 51. This is in Colonial style and shows a semi-circular finish on end of bottom tread and riser. Sections of the newels are octagon, and the rails are finished against the newels with a "goose-neck" curve and square. The landing turns at right angles.

The illustration offers a number of excellent suggestions for work other than for the stairs.

The examples shown of stairs in place, I think, are quite enough to give the workman an idea as to their treatment, so I will now offer a few designs for newels and balusters, and a few remarks as to their treatment.

There is no end to designs for newel posts, yet it is a strange fact that when a workman undertakes to design a newel for any particular stair he may be building, he finds it very difficult to decide upon the exact design he has in mind. This is owing to the fact that the workman possesses a certain amount of art instinct, and his mind requires for its satisfaction a newel suited to the fitness of the situation. An



RECEPTION HALL.
MAIN STAIRCASE.

Fig. 51.

elaborate stairway demands an elaborate newel and baluster, yet both must be in keeping with the surroundings as well as in keeping with the stairway. A good



Fig. 52.

illustration of this is exemplified in Fig. 51, where all the work seems to have a like character. Another illustration of the true fitness of things is shown in

Fig. 52. In this example there is a quiet Quaker-like repose both in stairway and finish, yet the observer cannot but be impressed with the wealth and dignity of the whole design. The newels are comparatively plain, yet they are effective and seem to be in the proper place. The whole stairway, paneling, strings, newels and balusters are in same finish as the woodwork in the hall. The mantel, which is quite plain, is chaste and in keeping with the general design. The first step is semi-circular at each end being returned against the newels. This stair and its appointments are well fitted for a Colonial house of the earlier period; in fact, it would do for almost any period of Colonial architecture.

The sketches shown at Figs. 53 and 54 exhibit styles of stairs, newels and balusters in

Elizabethan style. The balusters in Fig. 53 are square, and those running down the strings are worked on a rake; all the members being cut on the same incline as the "lay" of the string and rail. This is, of course, expensive, but it gives a fine appearance to the stairs. The sketch shown in Fig. 54 is taken from

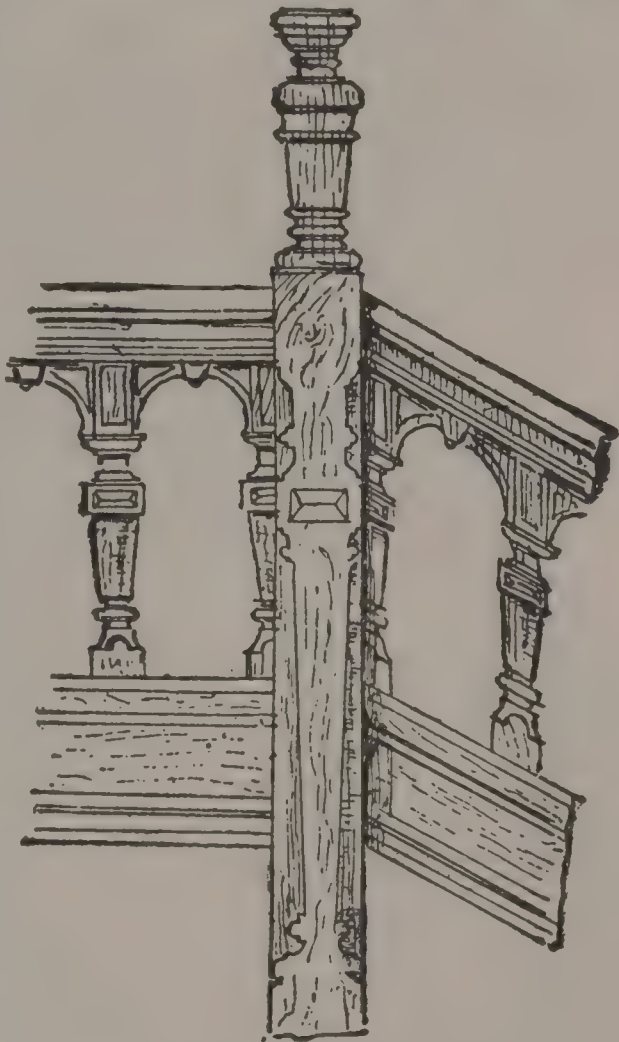


Fig. 53.

French work. It shows three balusters on each tread and carved brackets under end of nosing of treads. The plan of the rail is shown in the sketch at 3. The balusters are turned spiral, as will be seen. An alternate baluster is shown at No. 2.

I have given the proportion of riser and treads in an earlier paragraph, and it may be well at this point to

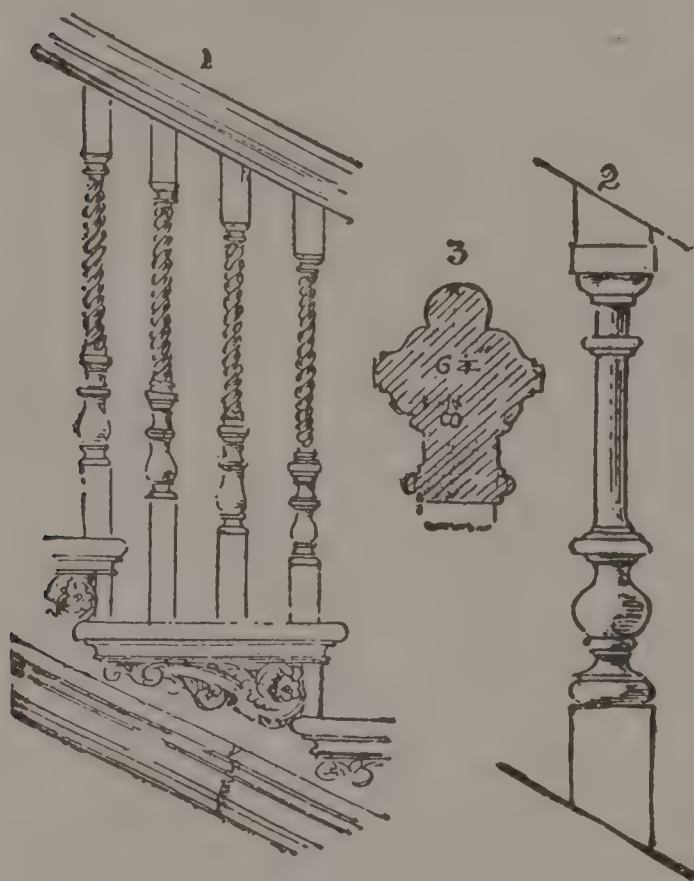


Fig. 54.

say something regarding the height a rail should be from the tread. An authority says "that the height from the treads at the nosings to the upper part of the handrail should be 2 ft. 7½ in.; at the landings the height of half the riser should be added, this variation in the height conducing to ease and safety, a person requiring more protection when he is

standing on a landing than when ascending a stairs. Two balusters are generally placed on every tread, one on the same plane as the riser. In the old close string staircases, where massive rectangular or turned balusters are seen, one to each step is common. Of handrails, the moulded is the handsomest; a roll member with cymas on each side, and a deep rail moulded at the sides with ovolos or astragals, is commonly met

with in the older examples and is very effective. (See sketch 54, 2, above.)”

In a recent text book on building construction the student is instructed, before planning a staircase, to know the position of doors and windows surrounding, so that the steps and the first and last riser may be



Fig. 55.

fixed accordingly. Advice of this kind is very well when a staircase has to be fitted in a given space; but the architect, in planning and designing the stairs, ought to proceed quite differently. He should first plan his stairs, as being the most important thing, and then arrange the hall thereto. The “going” of the flight or the positions of the first and last risers should not

be made to depend on the doorways and approaches, but these should be adjusted to the risers. Given a space to design a stairs in, it may be a mode of proceeding in some cases; but if any attempt is made to give the staircase a character of its own, its design should be undertaken *pari passu* with the hall in which it is to be placed. No architectural arrangement can



Fig. 56.

be possible under any other conditions.

Another style of stair is shown at Fig. 55, having turned newels at the bottom and square ones at the landings. This is a purely Colonial stair with the conventional shaped newel and baluster. All the rails in stairs of this kind are made straight and are fastened into the newels with either tenon or stair bolts or both, and glued.

The stair shown at Fig. 56 is taken from an English example of the Georgeon period. Both rail and newel are heavy, the latter being surmounted by a carved finial. In this example the risers are low and the treads wide, a characteristic of nearly all English stairs, a custom well worthy of imitation. The heavy newels employed in this stair give the whole design a

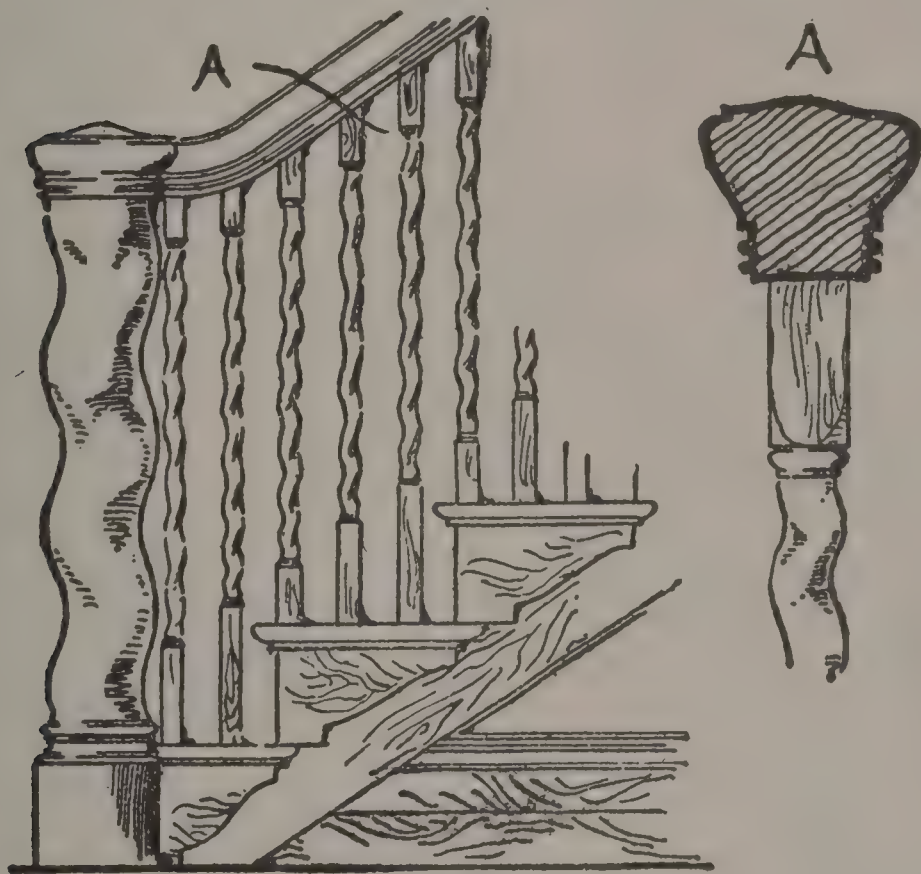


Fig. 57.

massive and substantial appearance. Of course, where a stair of this kind is intended to be placed, it must have plenty of room, as the run or "going" will require a good stretch owing to great width of tread, and the hall or reception room must be large to accommodate the stairs and be in keeping with them.

At Fig. 57, I show a portion of a stair having serpentine newel and baluster. This style of work is very

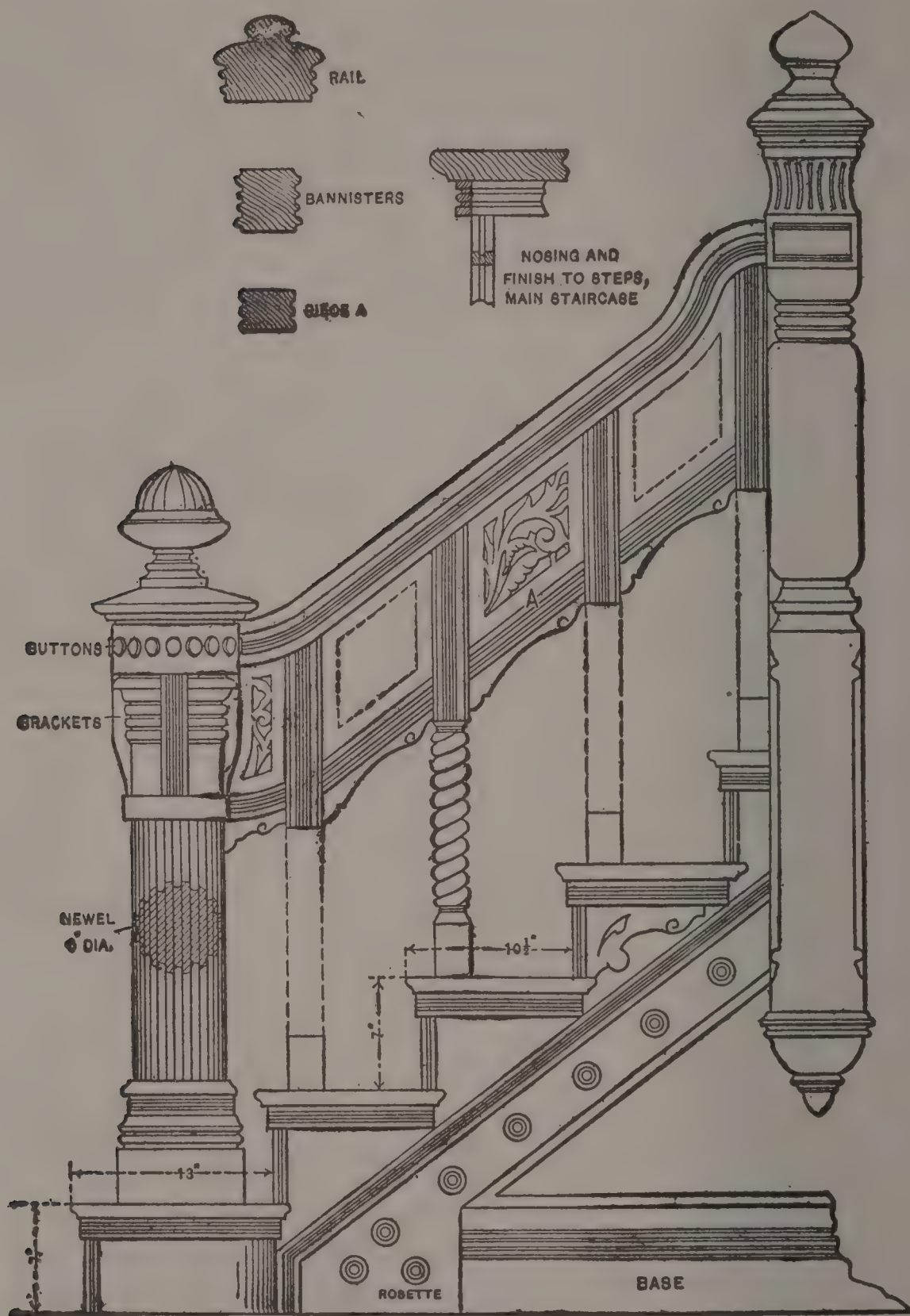


Fig. 58.

troublesome and is not much in favor, as the results are not in proportion to labor expended. A, A shows

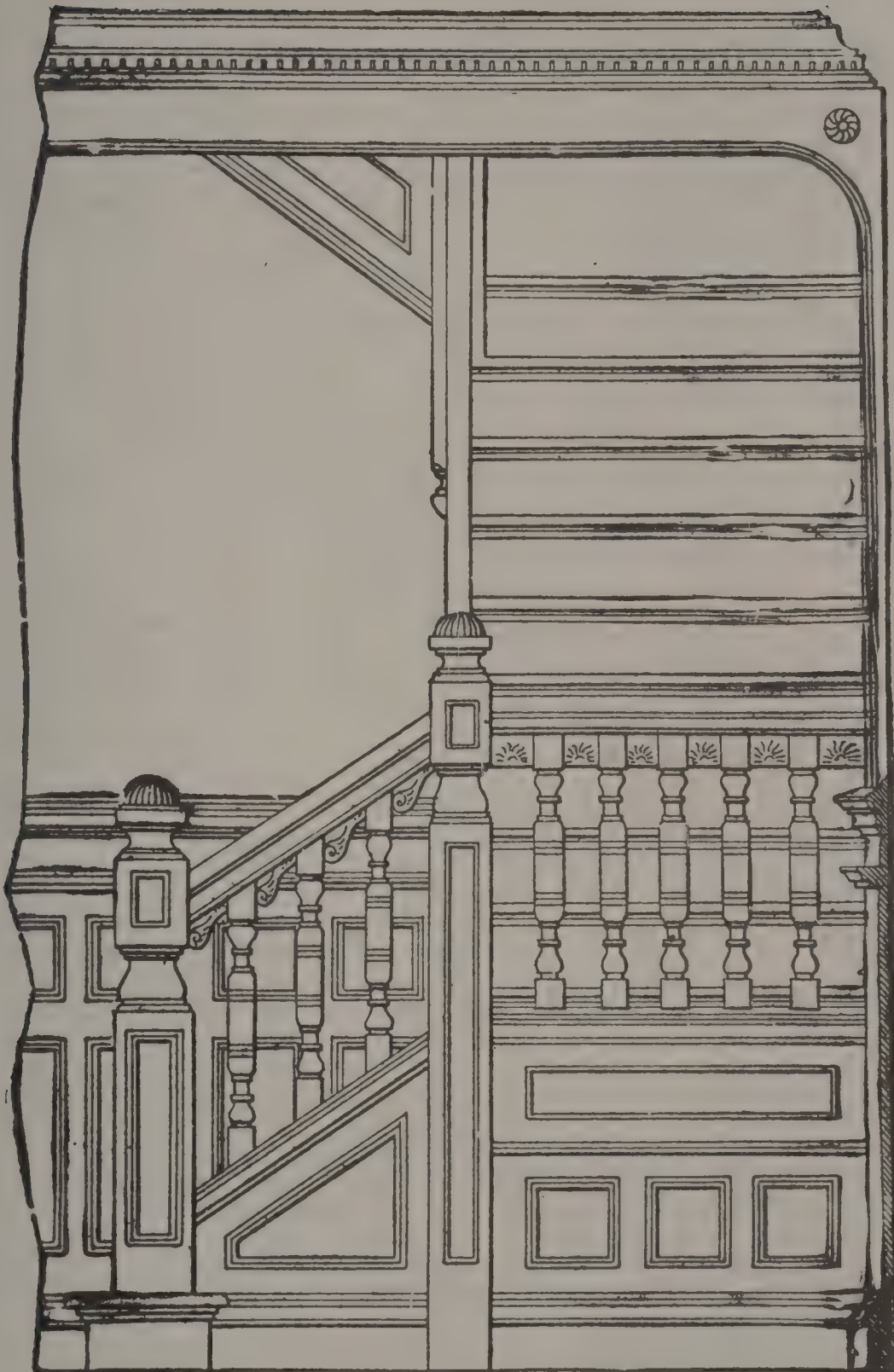


Fig. 59.

the style of rail which generally accompanies this style of ornamentation.

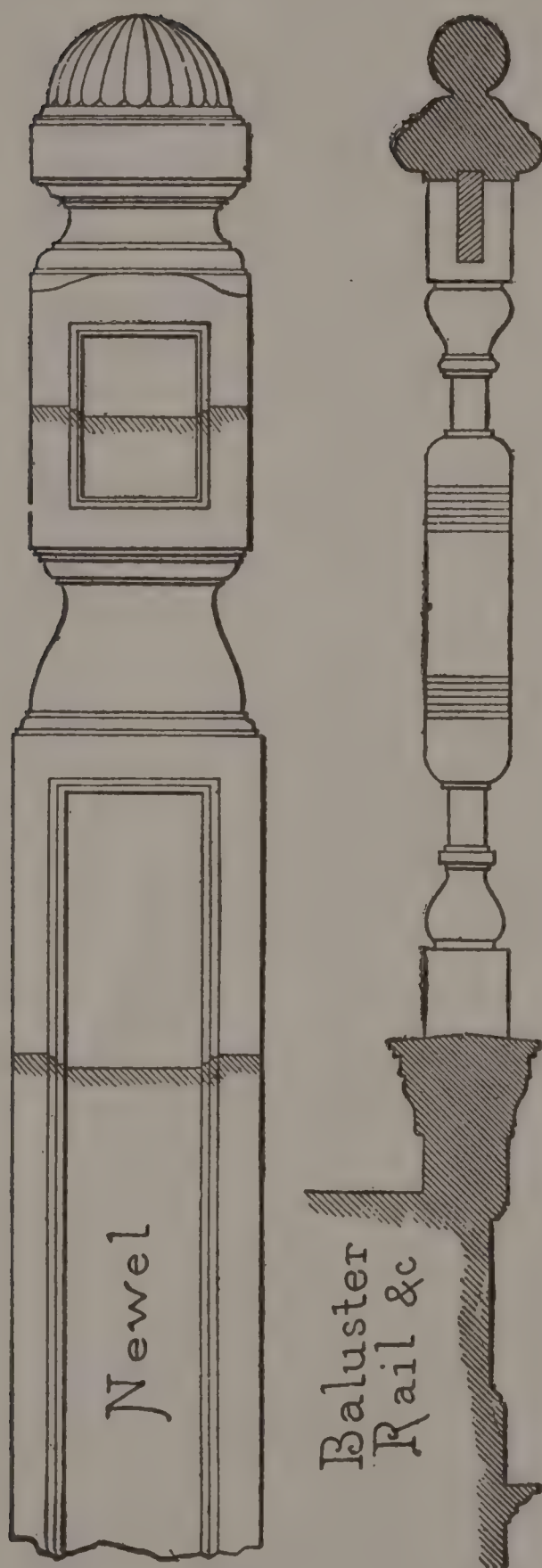


Fig. 60.

The illustration which is shown at Fig. 58 is adapted from *Carpentry and Building*, and is a good example of a modern stair. The paneling between the baluster at the top, marked A, is perforated. The treatment of the string is somewhat unusual, and it will be noticed that the nosings on the treads are worked to a flat ogee. The drop newel is quite plain, except the top, which is very nicely wrought. The rail enters the top newel with a goose-neck curve. The rosettes on the string are let in flush. The section of the fluted shaft of newel is circular, as shown by the shaded portion. Details of rail and treads are shown on the top of illustration.

Another style of stairs is shown at Fig. 59. A part of the paneled wainscot is shown, also lower spandril and

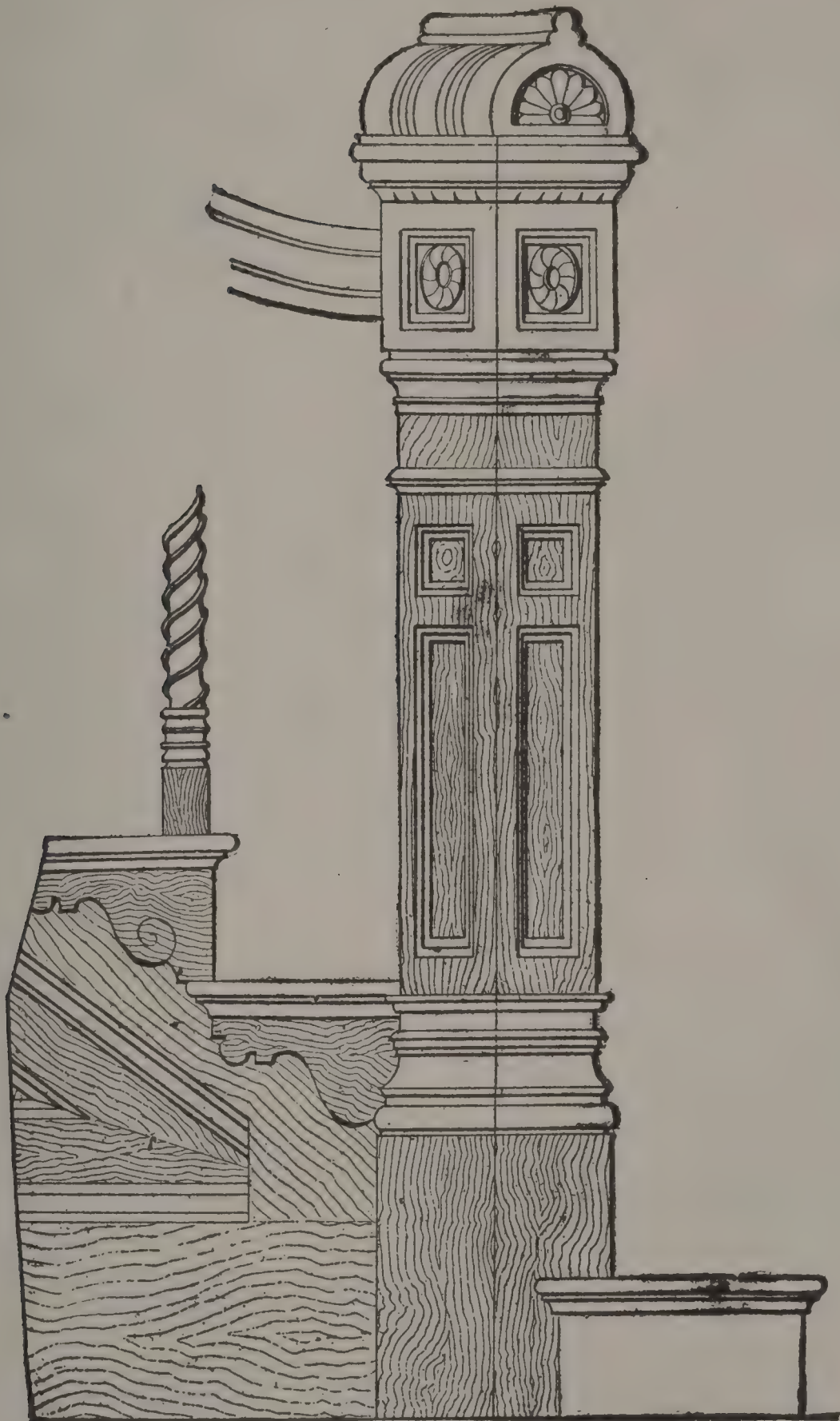


Fig. 61,

paneling of platform. Fig. 60 shows a portion of the newel and a baluster with section of rail drawn to a larger scale.

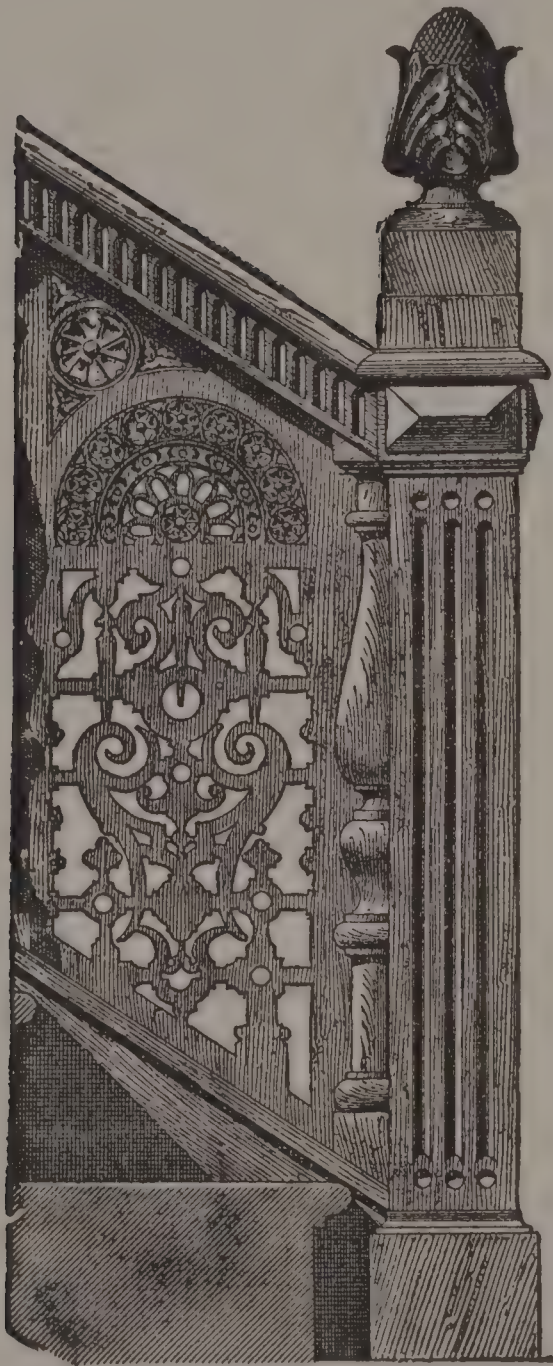


Fig. 62.

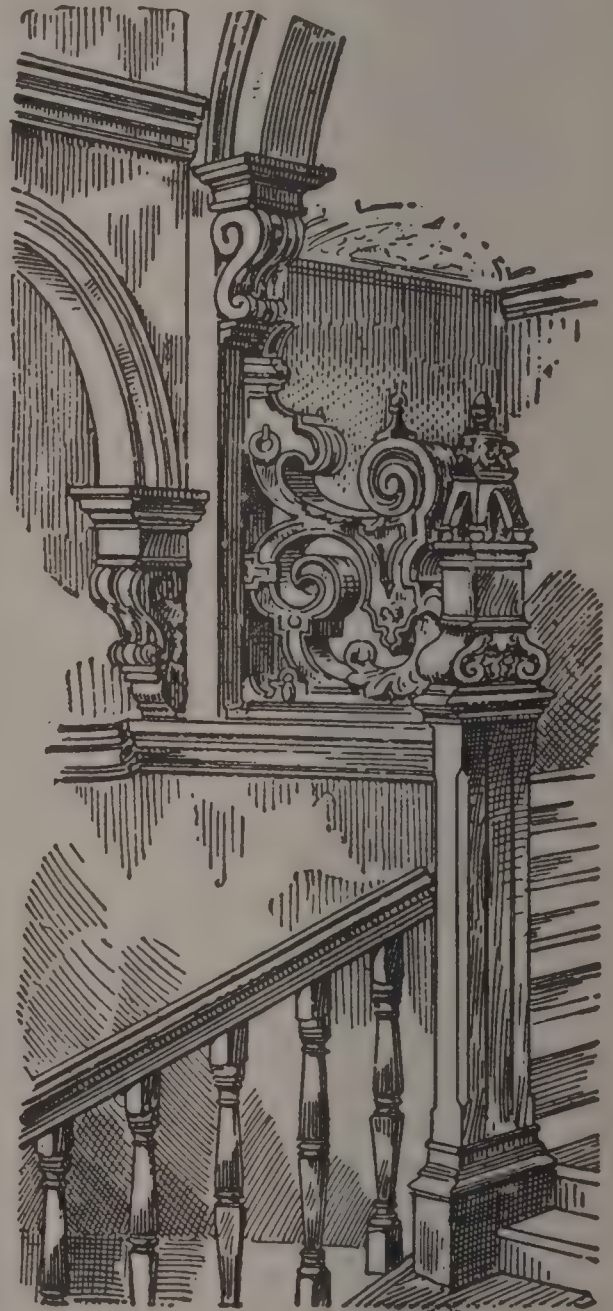


Fig. 63.

Fig 61 shows a built-up newel, and a couple of tread ends and a part of baluster; it also shows the rail with

ramp entering the newel post. The bottom tread is partly returned against the base of newel.

The example shown in Fig. 62 may be put down as one seldom required in this country, though I have

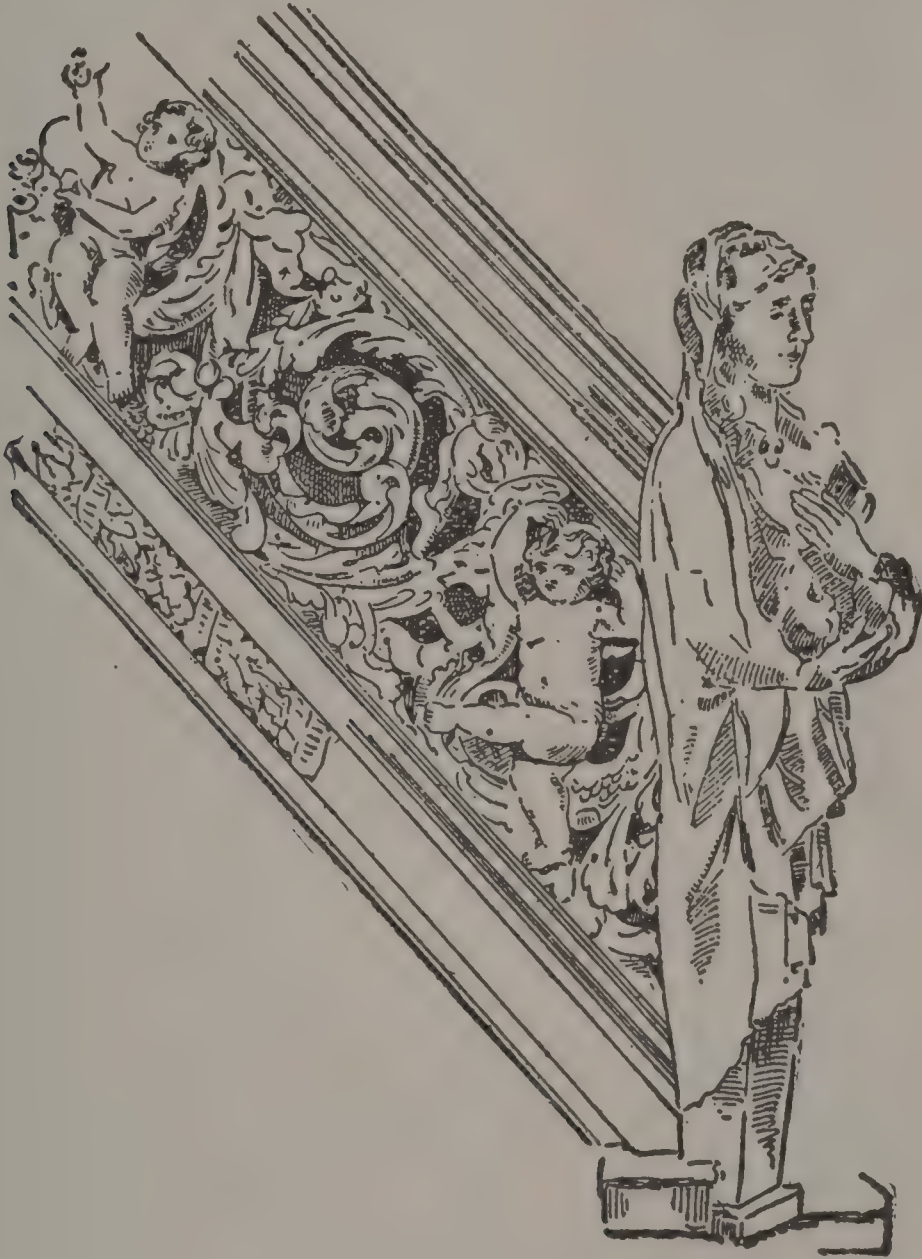


Fig. 64.

seen it, or one very similar, employed on a stairway leading to a gallery or speaker's platform. It is almost a solid balustrade.

Fig. 63 is of a style often employed in and about public buildings in England, Belgium and France,

In styles of this kind there is no regularity; the newels and balusters may be of a different pattern on each flight of stairs; they offer an abundance of opportunity for a display of originality of design on the part of the architect.

The example shown at Fig. 64 is taken from a stairway in St. Jacob's Church, Bruges. The newel is a

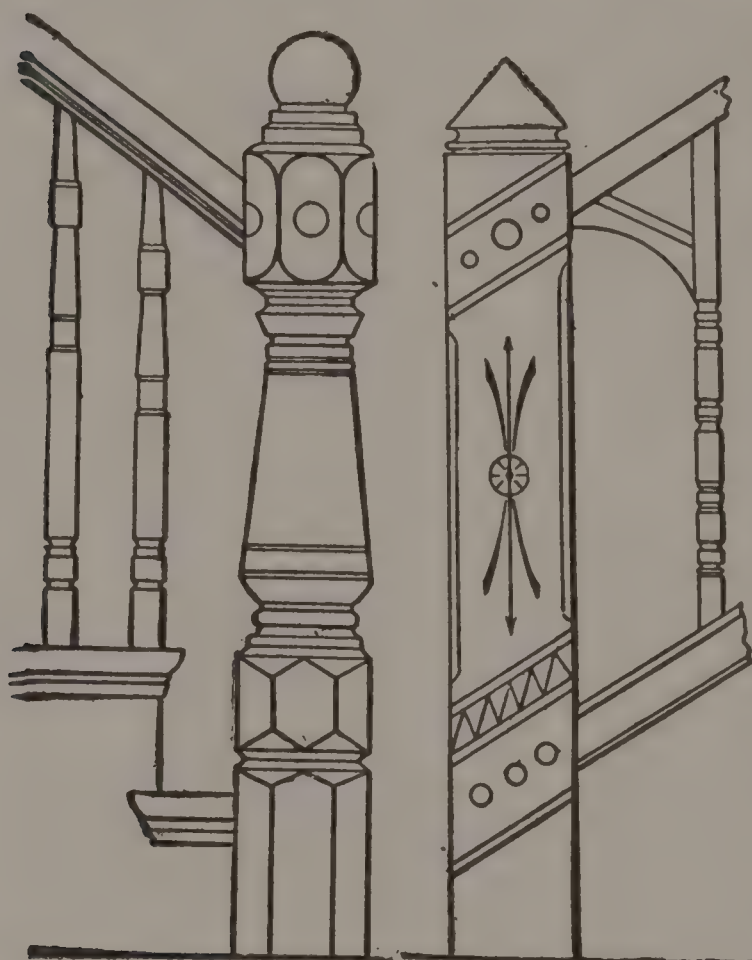


Fig. 65.

Fig. 66.

carved figure which is said to be one of the finest pieces of carving in Europe. The rail and sub-rail are heavy, and the spaces between them are filled with fine carvings instead of balusters. The string is also carved with a running wreath. The whole is made of heavy oak. The work is over two hundred years

old and is in excellent preservation at this date.

A couple of commonplace newels are illustrated at Figs. 65 and 66. The first is simply a turned post with an octagon base and flat facets, or neck, and surbase. The second example belongs to the so-called Queen Anne style. It is neither more nor less than a square post with a few ornaments worked on two sides on a

rake with the line of rail, and has chamfered corners. The ornaments are worked square across the lower and upper faces from the lines of the raking ornaments where they cut the angles of the post.

The example of newel shown in Fig. 67 is from the Cincinnati school of design, of which Benn Pitman was principal. This newel was carved by a young lady, Miss Louise Nourse, and is worked to over two inches relief projecting one inch over the border. The entire height of a newel is 4 ft. 9 in. It is illustrated here as an example of what may be done by the ordinary workman if he only apply himself to the task. Newel posts offer splendid opportunities to the carver.

The newels shown at Figs. 68 and 69 are octagon in section and are rather elaborate in finish. This style of newel is often made use of, but I confess I do not like them; they seem more like pedestals than newels, and are certainly vulgar when made up with different colored woods. They are also



Fig. 67.

unnecessarily costly, as they entail considerable labor in the making up; particularly is this true of Fig. 68,

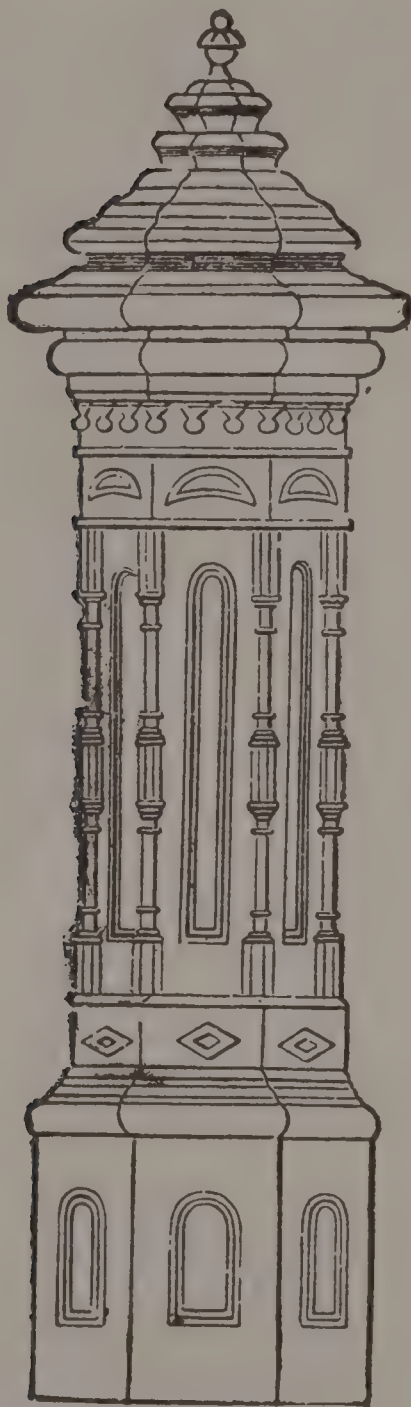


Fig. 68.

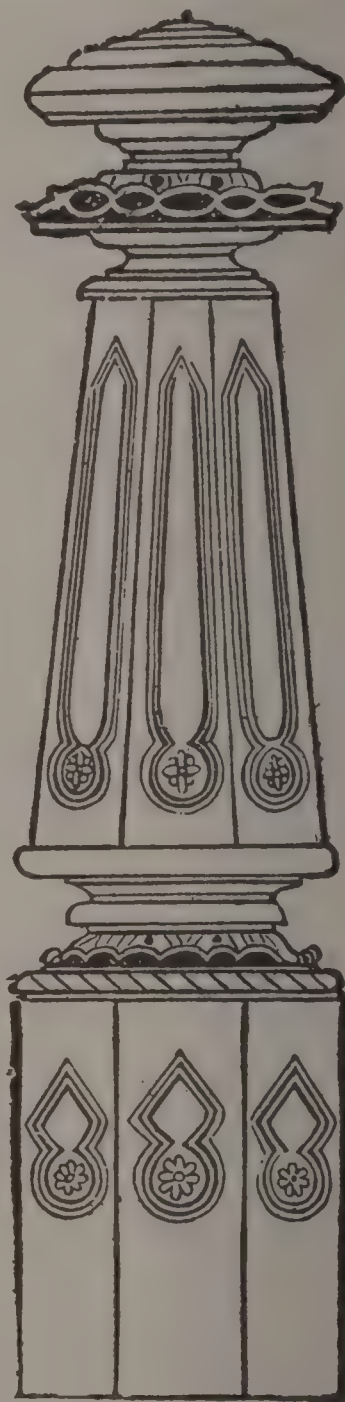


Fig. 69.

as all the mouldings must be mitered around the cap and the base. The result is not worth the labor, as the architectural effect is disappointing.

I will close my remarks on newels and newel posts by offering a few examples of quaint design culled from domestic and foreign sources; the example shown at Fig. 70 is taken from a stairway in Boston. This is a handsome design, but has one fault: the central column looks too much like a screw. It gives one the impression of a jack screw for raising great weights. If this column was fluted, the effect would be much more pleasing.

The carved newel shown at Fig. 71 is drawn from an example at

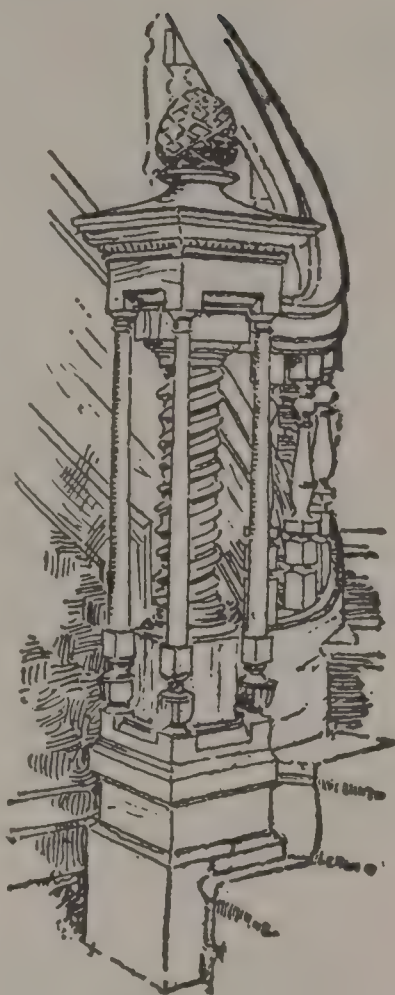


Fig. 70.

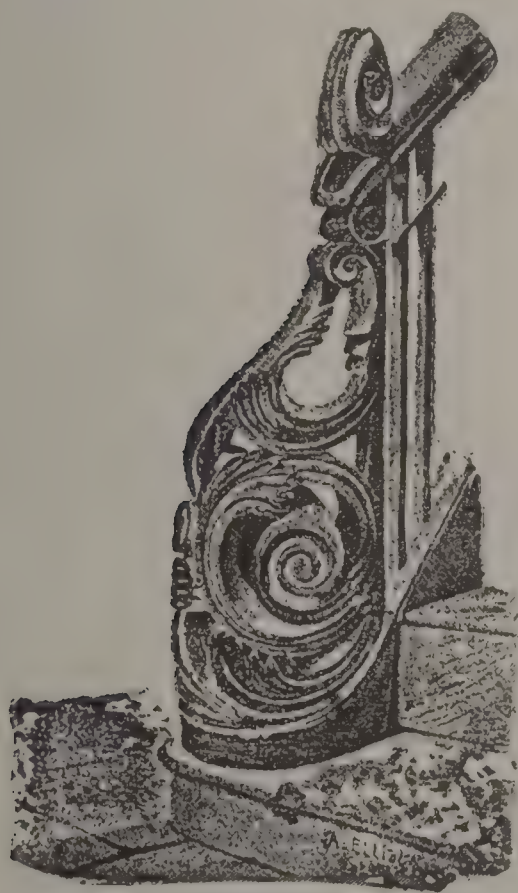


Fig. 71.

Argeles on the Spanish frontier near the Pyrenees. The one shown at Fig. 72 is at Tuz, a small town near Argeles.

The three examples shown at Figs. 73, 74 and 75 are from the same neighborhood as are those shown in Figs. 71 and 72. They are quaint and odd, and are generally placed in small narrow halls dimly lighted, and are apt to

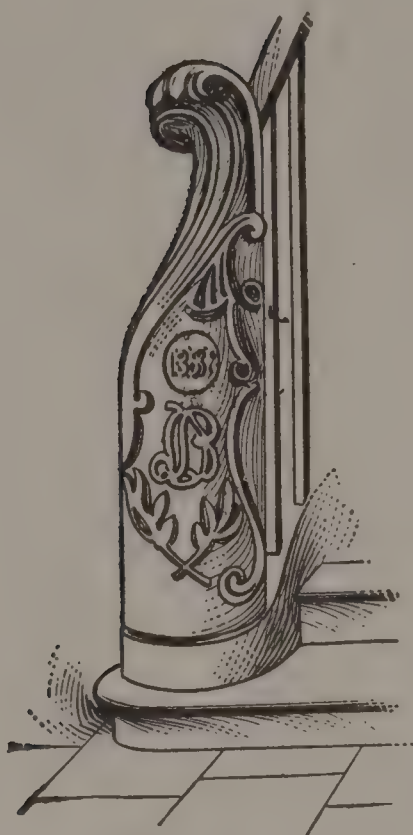


Fig. 72.

startle a stranger when he first enters. The examples offered are among the best, but there are some that rise above the head, and are topped off with hideous faces or grinning skulls and other uncanny things.

BALUSTERS OF VARIOUS KINDS

Before giving any designs for balusters, it may be well to say something about their arrangement with regard to their relation of length, rail and tread. Sometimes the architect who designs the stair may have very decided ideas as to the manner of arrang-



Fig. 73.



Fig. 74.

ing the balusters, and I give a few examples arranged differently in a stair having rail, string and baluster about the same. Fig. 76 shows one of the ordinary methods where the turnings are all of one length, and thus all the squares

run parallel with the handrail. In Fig. 77 the turnings are of two different lengths, the upper squares being all of one length and running parallel with the handrail, the bottom squares being all the same length and thus each pair being parallel with their respective treads, the middle member of the turning usually being arranged as shown. A method that is perhaps not much in general use is shown in Fig. 78, where

the turnings are all of the same length and the bottom squares equal, but the bottom ledges of the upper squares of each baluster run parallel with their respective treads, producing long and short upper squares alternately, as shown. It will be seen that

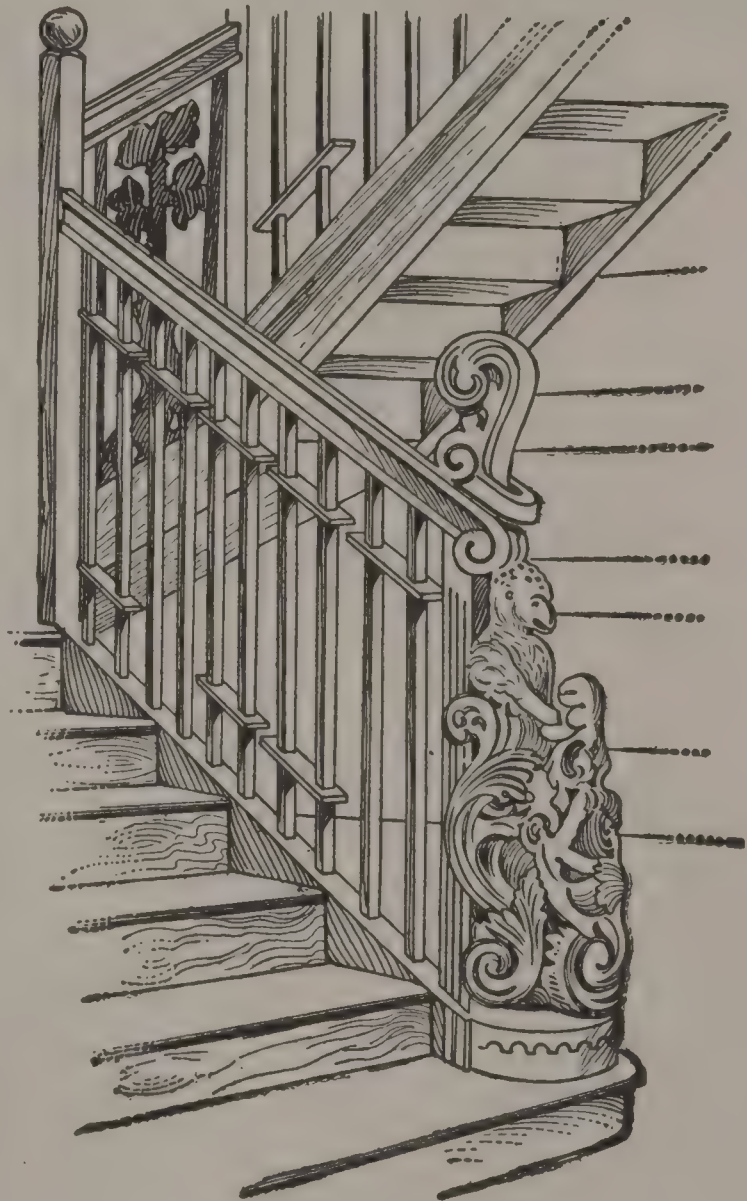


Fig. 75.

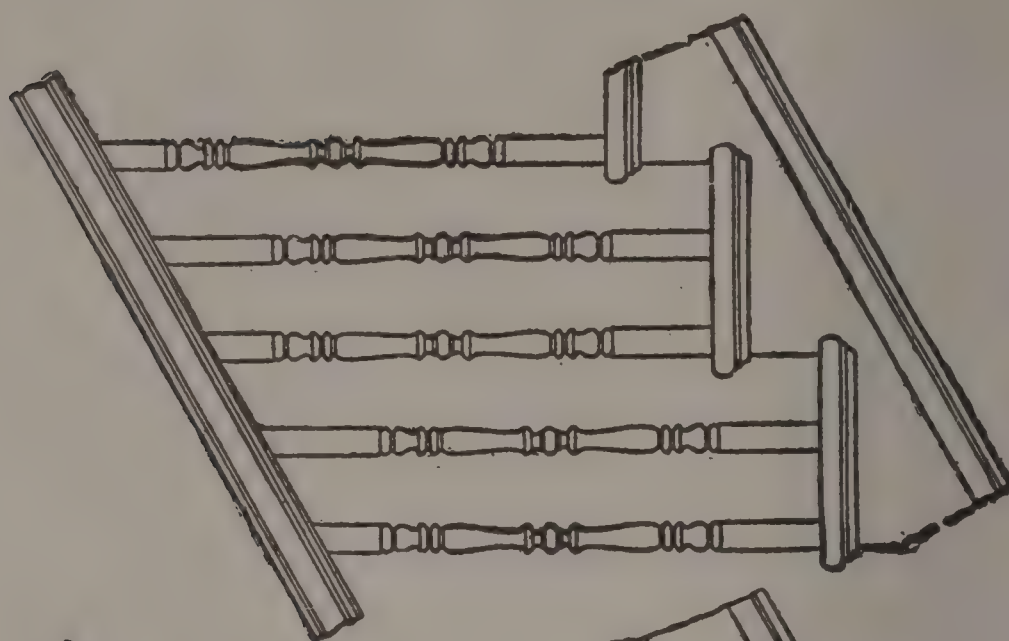


Fig. 78.

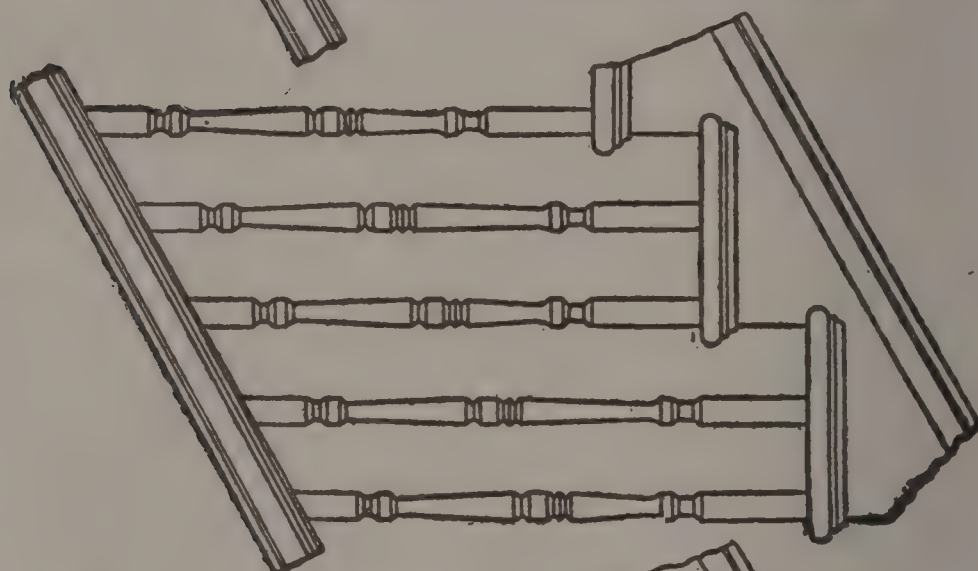


Fig. 77.

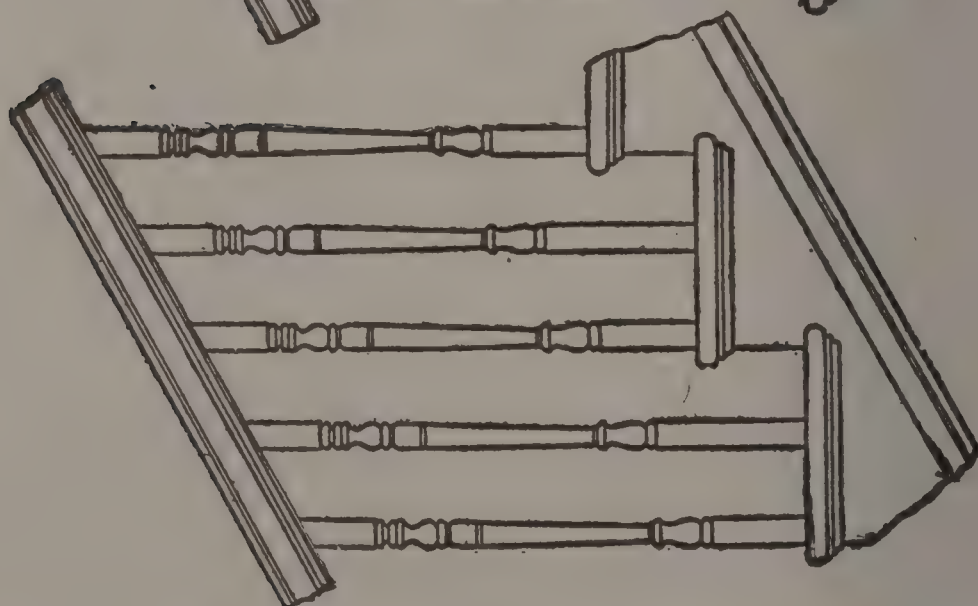


Fig. 76.

after all the difference in these examples is altogether in the lengths of the turned part of the baluster.

The patterns for balusters shown at Fig. 79 may be suggestive. Balusters of this kind may be obtained at any well-equipped factory any length or size that may be required.

A few Colonial balusters and a spiral newel are shown at Fig. 80. This makes a handsome termination for a stairway.

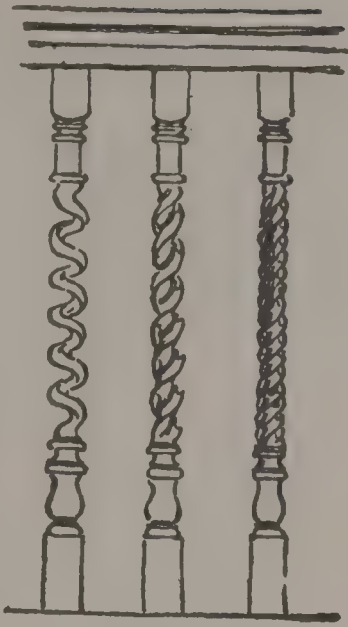
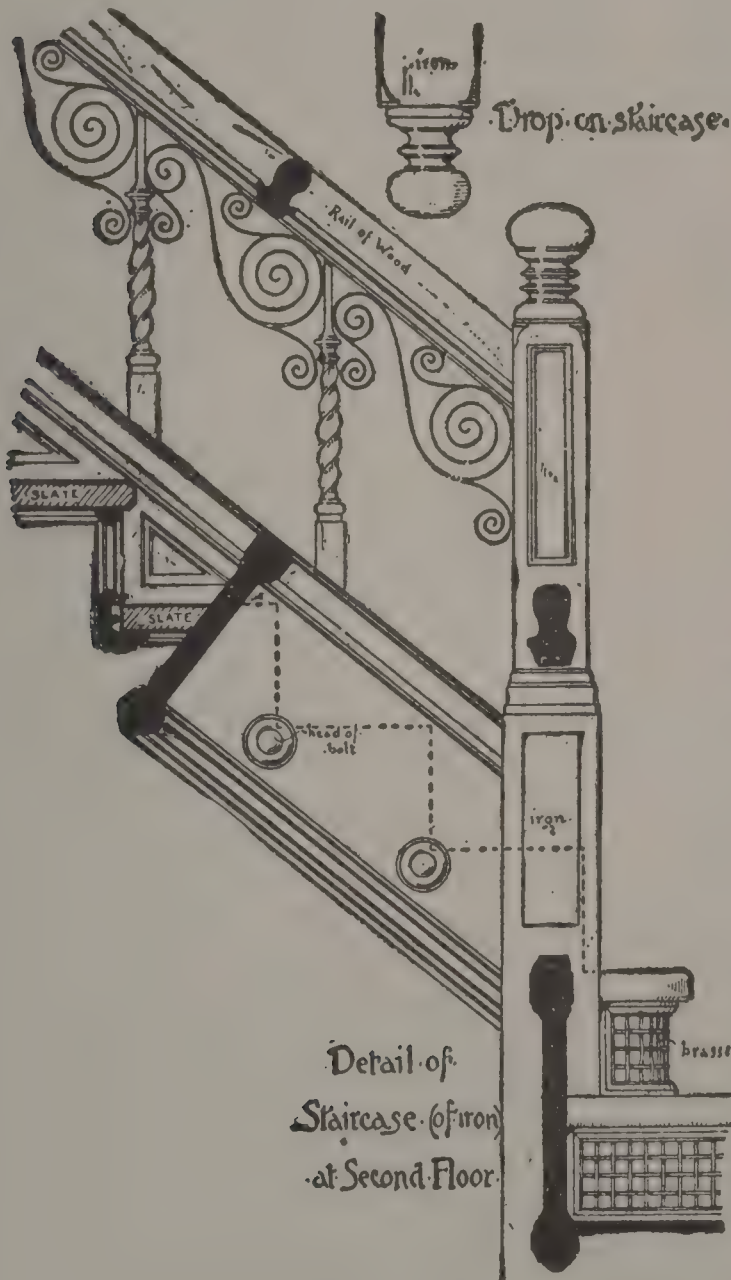


Fig. 79.



Detail of
Staircase (of iron)
at Second Floor.

Fig. 81.

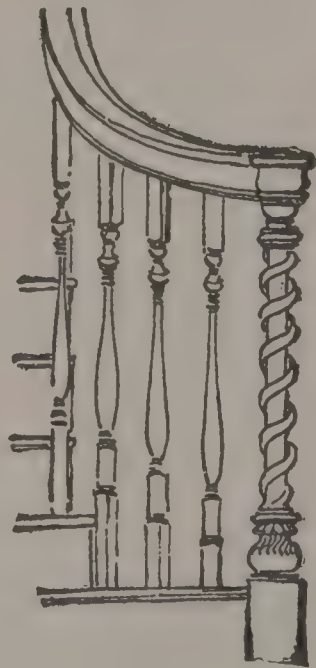


Fig. 80.

Samples of spiral balusters, with rail, newel, string and drop, are shown at Fig. 81. In this example the balusters are

shown reinforced by bent iron scroll work; this has a charming effect in many cases, and I know of one instance, in New York City, where the scroll work was of brass, the balusters enamelled cream, the rail solid mahogany, and the result was actually beautiful. The wood-

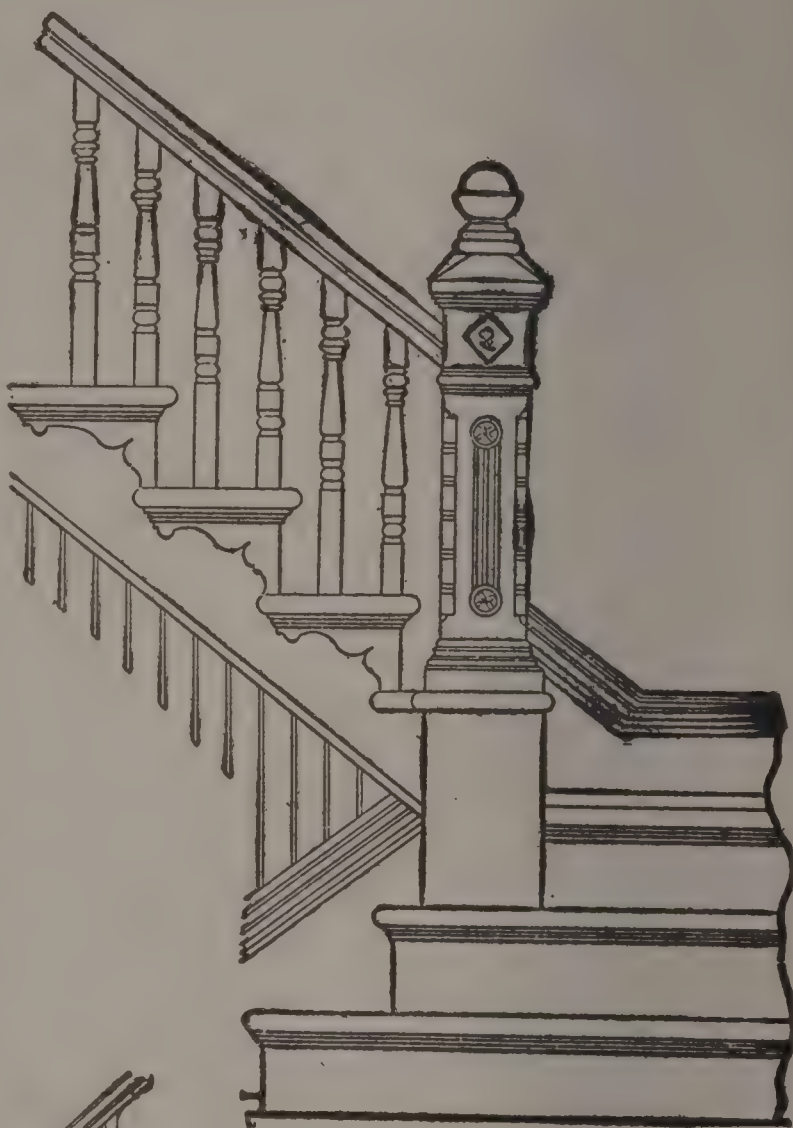


Fig. 82.

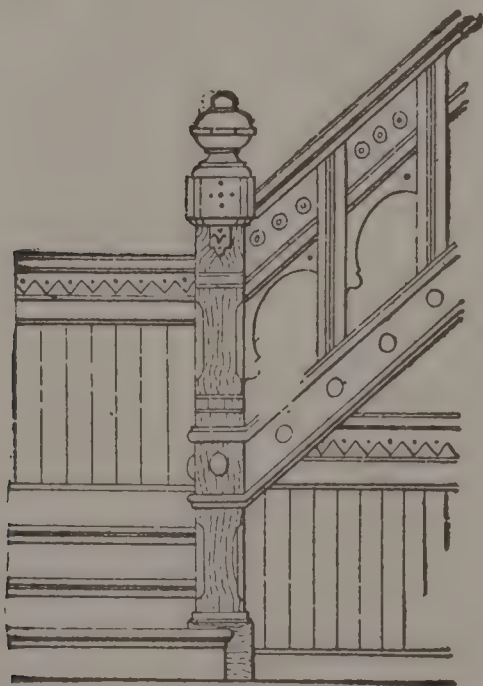


Fig. 83.

work in the hall was also cream-colored, and the light from the outside passed through amber-colored glass.

Another style of baluster, newel and string is exhibited at Fig. 82. The newel is formed at the first platform, there being three risers up to the platform. The balusters are simple, and the

whole illustration is given here more to show the method of raising the newel and balusters than for any other purpose.

Another style of baluster, string and rail is shown at Fig. 83. The baluster in this case is simply a square with two of its sides bevelled and cut in between the

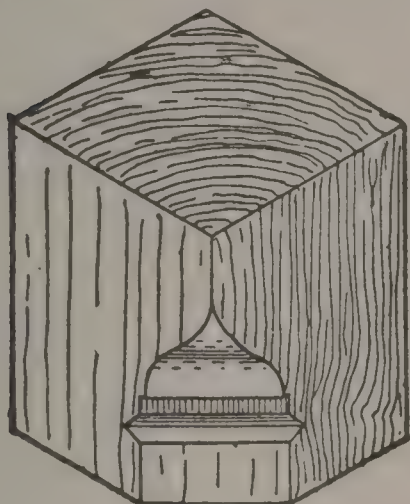


Fig. 84.

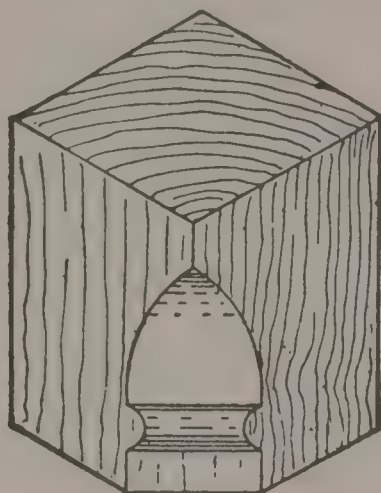


Fig. 85.

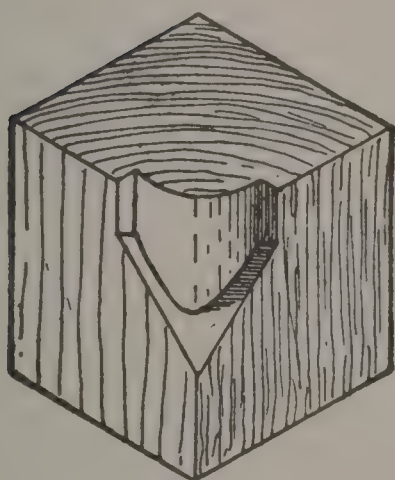


Fig. 86.

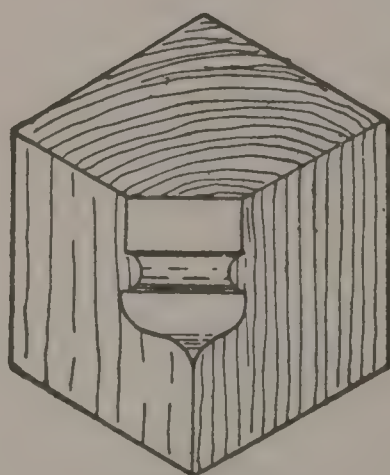


Fig. 87.

rail and the sub-rail. The little panels running raking with the rails are also cut in, or let into grooves in baluster and rail. Other portions of the illustration are self-explanatory.

These examples of newels and balusters, I think, are sufficient, as trade catalogues from factory and shop,

containing hundreds of set designs, may be obtained for the asking.

MISCELLANEOUS ITEMS

Under this head I purpose showing a few things not generally included in works of this kind, but which

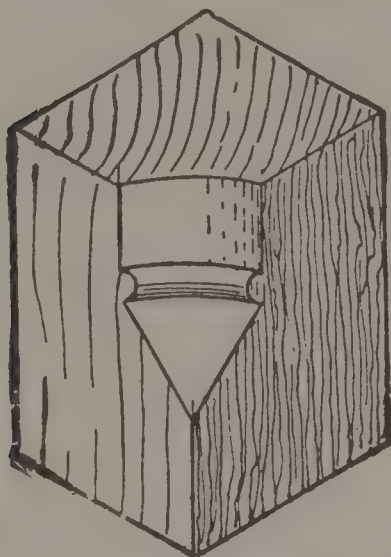


Fig. 88.

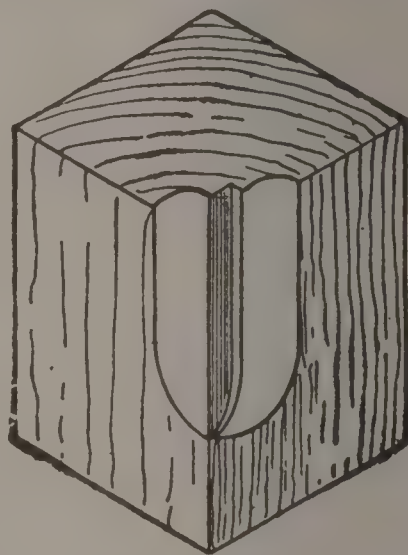


Fig. 89.



Fig. 90.

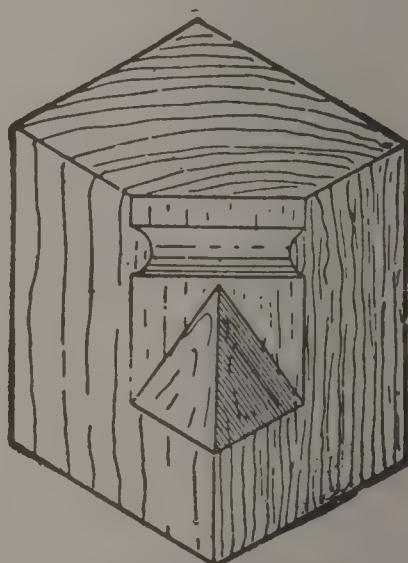


Fig. 91.

will be found very useful to the general workman as well as to the specialist in stair-building.

The illustrations shown in Figs. 84 to 91, inclusive, exhibit a number of different designs for stop cham-

fering. These will be found useful in determining the **style of** step for chamfering the corners of a newel post, and in many other instances as well. Some of these chamfers and stops are quite elaborate and will require considerable labor to work them out in good form; particularly is this true of Figs. 86 and 89, as one has a concave and the other a convex surface, and Fig. 89 has an ornamental termination.

Besides these styles of stops there are many others, the simplest of which is just a bevel ending of any pitch and the ogee ending, and several others of which nearly every workman is familiar.

The illustration shown at Fig. 92 gives the method of obtaining a reduced pattern for a bracket as required for the ends of winders. Upon the top edge of the bracket used for the flyers describe an equilateral triangle. Divide the contour of the bracket into a number of parts, and draw lines from divisions perpendicular to the top or base of the triangle.

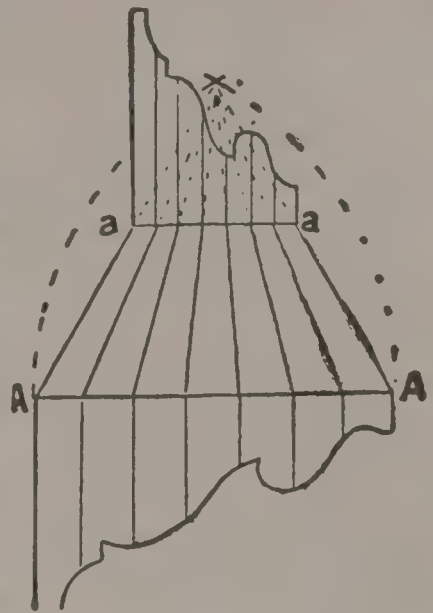


Fig. 92.

From these intersections draw lines to the apex of the triangle. Next mark upon the sides of the triangle, from the apex, the length of the bracket required. Join these points by a line, *a a*, which is parallel with the base, and upon the points where the line cuts the lines drawn to the apex, erect perpendiculars; make them equal in length to the corresponding lines drawn on the original bracket.

The eight illustrations shown in Fig. 93 give brackets and sections of handrails of various kinds, and is

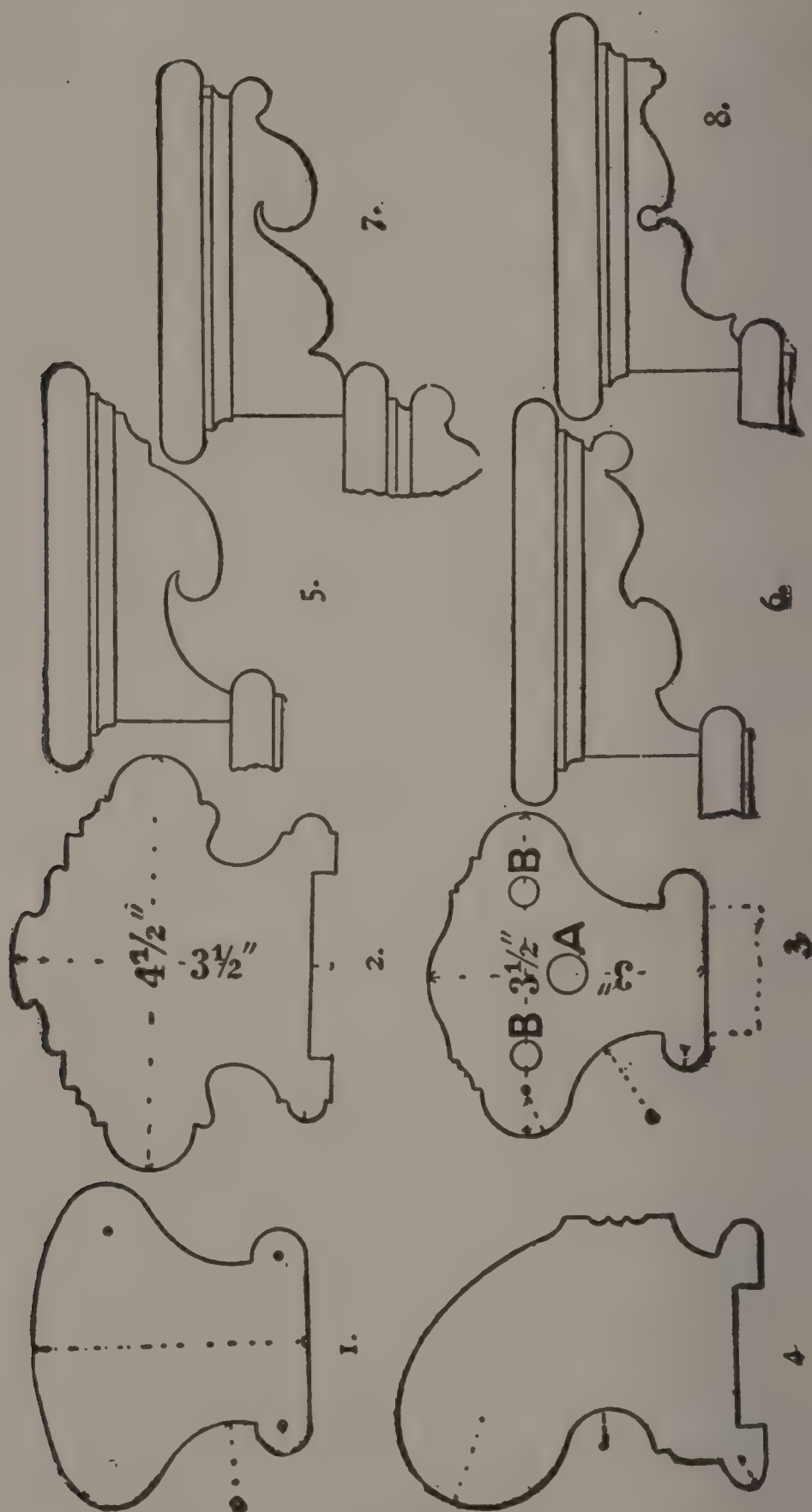


Fig. 93.

offered as a supplement to the page of handrail sections shown in part three of this work. In the examples given the centers of the curves forming the handrails are given, and the sizes of the rails are marked on the sections in two instances. The numbers 5 to 8, inclusive, show patterns for brackets which may be made to suit almost any style of stairs. Other patterns will be found illustrated in previous pages of this work in connection with examples of platform stairs.

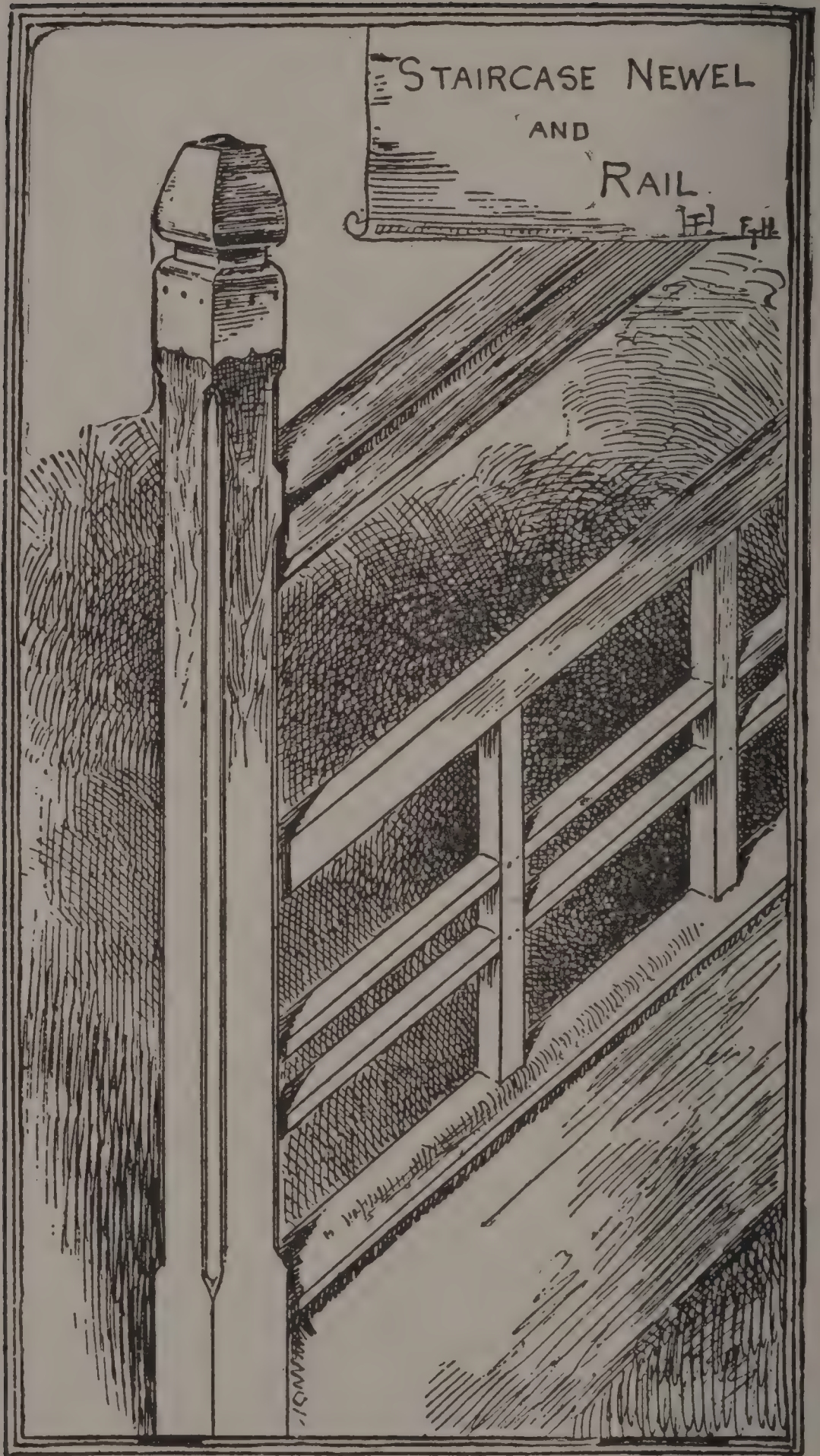
TABLES

The following tables which are taken from the *Builder and Woodworker*, but which I believe were first prepared by *The California Architect*, will be found very useful to those "figuring" on the run and rise of stairs. The spacing of the lines of figures into groups aids the eye in following the direction to the final point.

Directions.:—In the column beginning with the rise of step desired, find the height of story from top of floor to top of floor, then follow this line to the column under risers, which gives the number of risers. In the column under "treads" find the number of risers, *less one*, and on this line under the column of width of tread will be the length of run.

Risers.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
No. 1.....	0.6	6 $\frac{1}{4}$	0.6 $\frac{1}{2}$	0.6 $\frac{3}{4}$	1.1 $\frac{1}{2}$	0.7 $\frac{1}{8}$	7 $\frac{1}{4}$	0.7 $\frac{3}{8}$	7 $\frac{1}{2}$	0.7 $\frac{5}{8}$	0.7 $\frac{3}{4}$
2.....	1.0	1.0 $\frac{1}{2}$	1.1	1.6 $\frac{3}{4}$	1.7 $\frac{1}{2}$	1.2 $\frac{1}{4}$	2 $\frac{1}{8}$	1.2 $\frac{3}{4}$	1.3	1.3 $\frac{1}{4}$	1.3 $\frac{1}{2}$
3.....	1.6	2.1	2.2	2.8 $\frac{1}{2}$	2.9 $\frac{1}{2}$	2.4 $\frac{1}{2}$	3 $\frac{1}{8}$	2.5 $\frac{1}{2}$	2.6	2.6 $\frac{1}{2}$	2.7
4.....	2.0	2.7 $\frac{1}{4}$	2.8 $\frac{1}{2}$	3.3 $\frac{1}{2}$	3.4 $\frac{1}{2}$	3.0 $\frac{1}{4}$	3.7 $\frac{1}{2}$	3.0 $\frac{7}{8}$	3.1 $\frac{1}{2}$	3.2 $\frac{1}{8}$	3.2 $\frac{3}{4}$
5.....	2.6	3.1 $\frac{1}{2}$	3.3	3.9 $\frac{1}{2}$	4.1 $\frac{1}{4}$	3.6 $\frac{3}{4}$	4.4 $\frac{1}{2}$	3.8 $\frac{1}{4}$	3.9	3.9 $\frac{3}{4}$	3.10 $\frac{1}{2}$
6.....	3.0	3.7 $\frac{3}{4}$	4.2	4.4	4.6	4.1 $\frac{1}{2}$	5.0	4.3 $\frac{5}{8}$	4.4 $\frac{1}{2}$	4.5 $\frac{3}{8}$	4.6 $\frac{1}{4}$
7.....	3.6	4.8 $\frac{1}{4}$	4.10 $\frac{1}{2}$	5.5	5.7 $\frac{1}{2}$	5.4 $\frac{1}{4}$	6.3	5.6 $\frac{3}{8}$	5.7 $\frac{1}{2}$	5.8 $\frac{5}{8}$	5.9 $\frac{3}{4}$
8.....	4.0	5.2 $\frac{1}{2}$	5.11 $\frac{1}{2}$	6.6	6.9	6.1 $\frac{1}{2}$	7.7	6.9 $\frac{1}{8}$	7.10 $\frac{1}{2}$	7.11 $\frac{7}{8}$	7.1 $\frac{1}{4}$
9.....	4.6	6.3 $\frac{1}{4}$	6.7	7.0 $\frac{1}{2}$	7.3 $\frac{3}{4}$	7.1 $\frac{1}{2}$	8.1	7.4 $\frac{1}{2}$	8.1 $\frac{1}{2}$	8.3 $\frac{1}{8}$	8.4 $\frac{3}{4}$
10.....	5.0	7.10 $\frac{1}{2}$	7.8	8.1 $\frac{1}{2}$	8.5 $\frac{1}{4}$	8.3 $\frac{3}{4}$	9.4	8.7 $\frac{1}{4}$	9.10 $\frac{3}{4}$	9.10 $\frac{5}{8}$	9.0 $\frac{1}{2}$
11.....	5.6	8.9 $\frac{1}{4}$	8.9	9.2 $\frac{1}{2}$	9.6	9.1 $\frac{1}{8}$	10.6	9.2 $\frac{5}{8}$	10.0	10.2	9.8 $\frac{1}{4}$
12.....	6.0	9.4	9.2	10.10	10.3	10.1 $\frac{1}{2}$	11.1	10.10	10.7 $\frac{1}{2}$	10.9 $\frac{5}{8}$	10.4
13.....	6.6	10.11 $\frac{1}{4}$	10.11	11.4 $\frac{1}{2}$	11.9 $\frac{3}{4}$	11.3 $\frac{3}{8}$	12.3	11.8 $\frac{1}{2}$	11.3	11.5 $\frac{1}{4}$	10.11 $\frac{3}{4}$
14.....	7.0	11.5 $\frac{1}{2}$	11.11	12.4 $\frac{1}{2}$	12.11 $\frac{1}{4}$	12.5 $\frac{5}{8}$	13.10	12.10 $\frac{7}{8}$	12.6	12.8 $\frac{1}{2}$	11.7 $\frac{1}{2}$
15.....	7.6	12.6	12.5 $\frac{1}{2}$	13.0	13.6	13.0 $\frac{3}{4}$	14.7	13.6 $\frac{1}{4}$	13.9	13.11 $\frac{3}{4}$	12.3 $\frac{1}{4}$
16.....	8.0	13.0 $\frac{3}{4}$	13.6 $\frac{1}{2}$	14.1	14.7 $\frac{1}{2}$	14.10 $\frac{1}{8}$	15.2	14.9	14.4 $\frac{1}{2}$	14.7 $\frac{3}{8}$	12.11
17.....	8.6	14.7	14.15	15.2	15.9	15.5 $\frac{1}{4}$	16.4	15.4 $\frac{3}{8}$	15.0	15.3	13.6 $\frac{3}{4}$
18.....	9.0	15.0	15.2	16.0	16.4	16.0 $\frac{3}{8}$	17.9	16.11 $\frac{3}{4}$	15.7 $\frac{1}{2}$	15.10 $\frac{5}{8}$	13.4 $\frac{1}{2}$
19.....	9.5	15.6	16.0	17.0	17.6	17.5 $\frac{1}{4}$	18.2	17.16	16.3	16.6 $\frac{3}{4}$	14.2 $\frac{1}{2}$
20.....	10.0	16.0	16.4	18.0	18.6	18.10 $\frac{1}{4}$	19.4	18.17	17.6	17.17 $\frac{1}{8}$	14.10 $\frac{1}{4}$
21.....	10.6	16.6	17.0	19.0	19.6	19.11 $\frac{1}{4}$	20.0	19.18	18.0	18.18	15.6
22.....	11.0	17.0	17.4	20.0	20.6	20.12	21.0	20.19	18.6	19.19	16.1 $\frac{3}{4}$
23.....	11.6	17.6	18.0	21.0	21.6	21.13	22.0	21.20	19.2	19.20	16.9 $\frac{1}{2}$
24.....	12.0	18.0	18.4	22.0	22.6	22.14	23.0	22.21	19.8	20.21	17.5 $\frac{1}{4}$
25.....	12.6	18.6	19.0	23.0	23.6	23.15	24.0	23.22	20.4	20.22	18.1
26.....	13.0	19.0	19.4	24.0	24.6	24.16	25.0	24.23	21.0	21.23	
27.....	13.6	19.6	20.0	25.0	25.6	25.17	26.0	25.24	21.6	21.24	
28.....	14.0	20.0	20.4	26.0	26.6	26.18	27.0	26.25	22.2	22.25	

Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Treads.
0. 77⁄8	0. 8	0. 81⁄4	0. 9	0. 91⁄2	0. 10	0. 103⁄8	0. 11	0. 13	0. 14	1
1. 33⁄4	1. 4	1. 5	1. 6	1. 7	1. 8	1. 9	1. 10	2. 2	2. 4	2
1. 11⁹⁄8	2. 0	2. 11⁄2	2. 3	2. 41⁄2	2. 6	2. 71⁄2	2. 9	3. 3	3. 6	3
2. 71⁄2	2. 8	2. 10	3. 0	3. 2	3. 4	3. 6	3. 8	4. 4	4. 8	4
3. 33⁄8	3. 4	3. 61⁄2	3. 9	3. 111⁄2	4. 2	4. 41⁄2	4. 7	5. 5	5. 10	5
3. 111⁄4	4. 0	4. 3	4. 6	4. 9	5. 0	5. 3	5. 6	6. 6	7. 0	6
4. 71⁄8	4. 8	4. 111⁄2	5. 3	5. 61⁄2	5. 10	6. 11⁄2	6. 5	7. 7	8. 2	7
5. 3	5. 4	5. 8	6. 0	6. 4	6. 8	7. 0	7. 4	8. 8	9. 4	8
5. 107⁄8	6. 0	6. 41⁄2	6. 9	7. 11⁄2	7. 6	8. 101⁄2	8. 3	9. 9	10. 6	9
6. 63⁄4	6. 8	7. 1	7. 6	8. 11⁄2	8. 4	9. 9	9. 2	10. 10	11. 8	10
7. 25⁄8	7. 4	7. 91⁄2	8. 3	9. 6	9. 2	10. 6	10. 0	11. 11	12. 10	11
7. 101⁄2	8. 0	8. 6	9. 0	10. 31⁄2	10. 10	11. 8	11. 0	12. 13	14. 0	12
8. 63⁄8	8. 8	9. 21⁄2	9. 9	11. 1	11. 8	12. 3	12. 10	13. 0	15. 2	13
9. 21⁄4	9. 4	10. 71⁄2	10. 6	11. 101⁄2	12. 6	13. 11⁄2	13. 9	14. 1	16. 4	14
9. 101⁄8	10. 0	11. 4	11. 3	12. 8	13. 4	14. 0	14. 8	15. 3	17. 6	15
10. 6	10. 8	12. 0	12. 0	13. 51⁄2	14. 2	15. 10	15. 7	16. 4	18. 8	16
11. 17⁄8	11. 4	12. 01⁄2	12. 9	14. 3	15. 0	16. 8	16. 6	17. 5	19. 10	17
11. 93⁄4	12. 0	12. 9	13. 6	15. 01⁄2	16. 8	17. 6	17. 4	18. 8	21. 0	18
12. 55⁄8	12. 8	13. 51⁄2	14. 3	15. 10	16. 10	17. 10	17. 10	18. 9	22. 2	19
13. 11⁄2	13. 4	14. 2	15. 0	16. 71⁄2	17. 6	18. 4	18. 4	19. 3	23. 4	20
13. 93⁄8	14. 0	15. 7	16. 6	17. 5	18. 4	19. 3	19. 3	20. 2	24. 6	21
14. 51⁄4	14. 8	16. 31⁄2	17. 3	18. 21⁄2	19. 2	20. 11⁄2	20. 2	21. 1	25. 8	22
15. 11⁄8	15. 4	17. 0	18. 0	19. 0	20. 0	21. 0	21. 0	22. 0	26. 10	23
15. 9	16. 0	17. 81⁄2	18. 9	20. 91⁄2	21. 10	22. 9	22. 11	23. 1	28. 0	24
16. 47⁄8	16. 8	18. 5	19. 6	21. 41⁄2	22. 6	23. 71⁄2	23. 10	24. 2	29. 2	25
17. 03⁄4	17. 4	19. 11⁄2	20. 3	22. 2	23. 4	24. 6	24. 9	25. 3	30. 4	26
17. 85⁄8	18. 0	19. 10	21. 0	23. 2	24. 4	25. 6	25. 8	26. 4	31. 6	27
18. 41⁄2	18. 8	19. 3	21. 0	24. 6	26. 8	28. 0	28. 8	30. 4	32. 8	28



STAIRCASE NEWEL AND RAIL

A GLOSSARY OF TERMS USED IN STAIR-BUILDING AND HAND- RAILING

A Flight.—A continued series of steps without a break.

Axis.—In *architecture* an imaginary line through the center of a column, etc., or its geometrical representation; where different members are placed over each other so that the same vertical line on the elevation divides them equally, they are said to be on the same axis, although they may be on different planes; thus triglyphs and modillions are so arranged that one coincides with the axis or line of axis of each column; in like manner the windows or other openings in the several stories of a façade must all be in the same respective axis whether they are all of the same breadth or not. In *geometry*, the straight line in a plane figure about which it revolves to produce or generate a solid. . In *mechanics*, the axis of a balance is the line upon which it moves or turns. In *turning*, an imaginary line passing longitudinally through the middle of the body to be turned, from one point to the other of the two cones, by which the work is suspended or between the back center and the center of the collar of the puppet which supports the end of the mandril at the chuck.

Baluster.—A small column or post turned of different forms and sizes, forming an ornamental enclosure and supporting the handrail; generally two to a step.

Balustrade.—A series or row of balusters joined by a rail, serving for a rest to the arms, or as a fence or enclosure to balconies, altars, staircases, etc. Balustrades when intended for use or against windows or flights of steps, terraces and the like, should not be more than 3 feet 6 inches, nor less than 3 feet in height. When used for ornament, as on the summit of a building, their height may be from two-thirds to four-fifths of the entablature whereon they are employed, and this proportion is to be taken exclusive of their zoccolo or plinth, so that from the proper point of sight the whole balustrade may be exposed to view. There are various species of balusters; if single-bellied the best way is to divide the total height of the space allotted for the balustrade into thirteen equal parts, the height of the baluster to be eight, of the base three, and of the cornice two of those parts; or divide the total height into fourteen parts, making the baluster eight, the base four, and the cornice two. If double-bellied the height should be divided into fourteen parts, two of which are to be given to the cornice, three to the base and the remainder to the baluster.

The distance between two balusters should not be more than half the diameter of the baluster in

its thickest part, nor less than one-third of it; but on inclined planes the intervals should not be quite so wide.

Butt Joint.—An end joint made at right angles to the central tangent of a wreath piece; and also an end joint made at right angles to any straight length of handrail.

Carriage.—The timber work which supports the steps of a wooden stair.

Close String.—In dog-leg stairs a staircase without an open newel.

Cockel Stairs.—A winding staircase.

Circular Stairs are stairs with steps planned in a circle toward the center of which they all converge and are all winders.

Curve-out.—A concave curve of the face of a front-string at its starting.

Curtail Step.—The first step by which a stair is ascended, finishing at the end in a form of a scroll following the plan of the handrail.—*Nicholson*.

Cylinder.—A *cylinder* is a solid described by geometers as generated by the rotation of a rectangle about one of its sides supposed to be at rest; this quiescent side is called the *axis* of the *cylinder*, therefore the base and top of the cylinder are equal or similar circles.

A *prism* is a solid, whose base and top are similar right line figures, with sides formed in planes, and rising perpendicularly from the base to the top.

The *cylinder*, so called by *joiners*, is a solid figure compounded of the two last mentioned figures; its base is composed of a *semicircle* joined to a *right-angled* parallelogram. This last compound figure is intended whenever the word *cylinder* occurs in the preceding work unless the word geometrical be prefixed.

Dog-legged Stairs.—Such as are solid between the upper flights, or those that have no well-hole; and the rail and balusters of both the progressive and retrogressive flight fall in the same vertical plane. The steps are fixed to strings, newels and carriages; and the ends of the steps of the inferior kind terminate *only* on the side of the string.—*Nicholson*.

Elliptic Stairs.—Stairs that are elliptic on the plan, the treads all converging, but not to one center like those of a circular stair.

Face Mould.—A section produced on any inclined plane vertically over a curved plan of handrail.

Flight of Stairs.—In a staircase the series of steps from one landing place to another. Thus the same staircase between one floor and another may consist of more than one flight of steps, the flight being reckoned from one landing to another.

Front String.—The string on that side of the stair over which the handrail is placed.

Fillet.—A band $1\frac{1}{4}$ inches wide by $\frac{1}{4}$ inch thick nailed to the face of a front string below the cove and extending the width of a tread.

Flyers.—Steps in a flight that are parallel to each other.

Geometrical Stair.—A flight of stairs supported only by the wall at one end of the steps.

Half-space, or resting place.—The interval between two flights of steps in a staircase.

Hall.—The first large apartment on entering a house; the public room of a corporative body ; a manor-house.

Handrail.—A variously formed and sized rail running parallel to the inclination of the stairs for holding the balusters.

Hollow Newel.—An opening in the middle of the staircase. The term is used in contradistinction to *solid newel*, into which the ends of the steps are built. In the hollow newel, or well-hole, the steps are only supported at one end by the surrounding wall of the staircase, the ends next the hollow being unsupported.—*Nicholson*.

Helix.—The small twist under the head of a Corinthian column.

Housing.—The space excavated out of a body, for the insertion of some part of the extremity of another in order to fasten the two together; thus the string-board of a stair is most frequently excavated, or notched out for the reception of steps. The term is also applied to a niche for containing a statue.—*Nicholson*.

Joint.—The surface of separation between two bodies brought into contact and held firmly together,

either by some cementing medium or by the weight of one body lying upon another. A joint is not merely the contact of two surfaces, though the nearer they approach the more perfect the joint. In masonry the distance of the planes intended to form a joint is comparatively considerable because of the coarseness of the particles which enter into the composition of the cement.

Kerf.—A slit or cut in a piece of timber or in a stone, usually applied to that made by a saw or axe.

Keys.—In naked flooring, pieces of timber fixed in between the joists by mortise and tenon; when these are fastened with their ends projecting against sides they are termed strutting pieces.

Keys.—Pieces inserted in boards to prevent warping.

Knee.—A convex bend in the back of a handrail.

Knee.—A part of the back of a handrailing of a convex form, the reverse of a *ramp*, which is a back of a handrail and is concave; also any piece of timber bent to an angular joint.

Landing.—Horizontal resting-place in a flight.

Newel.—The central column around which the steps of a circular staircase wind; the principal post at the angles and foot of a staircase.

Newel.—In architecture the upright post or central column around which the steps of a circular staircase are made to wind, being that part of the staircase by which they are sustained.

The newel is properly a cylinder of stone or

wood, which bears on the ground and is formed by the ends of the steps of the winding stairs.

There are also newels of wood, which are pieces of wood placed perpendicularly, receiving the tenons of the steps of wooden stairs into their mortises, and wherein are fitted the shafts and rests of the staircase and the flight of each story. In some of the Tudor and Elizabethan residences some very fine examples may be seen of the newel richly ornamented and adding much to the beauty of the staircase.—*Nicholson*.

Nosing.—The outer or front edge of the step.

Pitching Piece.—A horizontal timber with one of its ends wedged into the wall at the top of a flight of stairs to support the upper end of the rough strings.

Pitch.—Angle of inclination of the stairs.

Pitch-board.—A piece of thin board in the form of a right-angled triangle, one of the sides of the right angle equal to a rise.

Ramp.—A concave or convex curve or easement of an angle, as sometimes required at the end of a wreath or an adjoining straight rail.

Rise.—The vertical rise between the treads.

Riser.—The board forming the vertical portion of the front of a step.

Run.—Of a flight of stairs, the horizontal distance from the first to the last riser.

Scroll.—A carved curvilinear ornament, somewhat

resembling in profile the turnings of a ram's horn.
—*Hatfield*.

Splay.—A slanting or beveling in the sides of an opening to a wall for a window or door, so that the outside profile of the window is larger than that of the inside; it is done for the purpose of facilitating the admission of light. It is a term applied to whatever has one side making an oblique angle with the other; thus the heading joists of a boarded floor are frequently splayed in their thickness. The word *fluing* is sometimes applied to an aperture in the same sense as *splayed*.

Spring Bevel of a Rail.—The angle made by the top of the plank with a vertical plane touching the ends of the rail piece which terminates the concave side.

Squaring a Handrail.—The method of cutting a plank to the form of a rail for a staircase so that all the vertical sections may be right angles.

Spiral.—In *geometry*, a curve line of the circular kind, which in its progress always recedes more and more from its center. In *architecture*, a curve that ascends winding about a cone or spire so that all its points continually approach its axis.

Spandril.—The angle formed by a stairway.

Stairs (from the Saxon *stæger*).—In a building, the steps whereby to ascend and descend from one story to another.

The breadth of the steps of stairs in general use in common dwelling houses is from 9 to 12 inches, or about 10 inches medium. In the best staircases of fine houses or public edifices the breadth ought never to be less than 12 inches nor more than 18 inches. It is a general maxim that the greater breadth of a step requires less height than one of less breadth; thus, a step of 12 inches in breadth will require a rise of $7\frac{1}{2}$ inches, which may be taken as a standard by which to regulate those of other dimensions; so that multiplying 12 inches by $5\frac{1}{2}$ we shall have 66; then supposing a step to be 10 inches in breadth the height should be $66 \div 10 = 6\frac{3}{5}$ inches, which is nearly, if not exactly, what common practice would allow. The proportion of steps being thus regulated the next consideration is the number requisite between two floors or stories which will be ascertained by supposing the breadth of the steps given, say 10 inches each, as depending on the space allowed for the staircase, and this, according to the rule laid down, will require a rise of nearly 7 inches; suppose then the distance from floor to floor to be 13 feet 4 inches, or 160 inches, $160 \div 7 = 22\frac{6}{7}$, which would be the number required; but as all the steps must be of equal heights we should rather take 23 risers, provided the staircase room would allow it, and so make the height of each somewhat less than 7 inches.

The most certain method of erecting a staircase is to provide a rod of sufficient length to reach from one floor to another, divided into as many equal parts as the intended number of risers, and try every step as it is set to its exact height. The breadth of the staircase may be from 6 to 20 feet according to the use or application of the building or the form or proportions of the plan.

If the steps be less than 3 feet in length the staircase becomes inconvenient for the passing of furniture, as is frequently the case in small houses.

Though it is desirable to have such rules as are here laid down for regulating the proportion of the heights, breadths and lengths of steps, architects and workmen cannot be so strictly tied to them but that they may vary them as circumstances may demand.—*Nicholson*.

Stairs are constructions composed of horizontal planes elevated above each other, forming steps, affording the means of communication between the different stories of a building.

In the distribution of a house of several stories the stairs occupy an important place. In new constructions their form may be regular, but in the reparation or remodeling of old buildings the first consideration is generally to make the distribution suitable for the living and sleeping rooms, and then to convert to the use of the stairs the spaces which may remain, giving to them such forms in

plan as will render them agreeable to the sight and commodious in the use.

When houses began to be built in stories the stairs were placed from story to story in straight flights like ladders. They were erected on the exterior of the building, and to shelter them when so placed great projection was given to the roofs. To save the extent of space required by straight flights the stairs were made to turn upon themselves in a spiral form, and were inclosed in turrets. A newel, either square or round, reaching from the ground to the roof, served to support the inner ends of the steps, and the outer ends were let into the walls or supported on notched boards attached to the walls.

At a later period the stairs came to be inclosed within the building itself, and for a long time preserved the spiral form which the former situation had necessitated.

Definitions.—The apartment in which the stair is placed is called the *staircase*.

The horizontal part of a step is called the *tread*, the vertical part the *riser*, the breadth or distance from riser to riser the *going*, the distance from the first to the last riser in a flight the *going of the flight*.

When the risers are parallel with each other the stairs are, of course, *straight*.

When the steps are narrower at one end than the other they are termed *winders*.

When the bottom step has a circular end it is called a *round-ended step*; when the end is formed into a spiral it is called a *curtail step*.

The wide step introduced as a resting place in the ascent is a *landing*, and the top of a stair is also so called.

When the landing occupies the whole width of the staircase it is called a *half-space*.

When the landing at a resting place is square it is designated a *quarter-space*.

So much of a stair as is included between two landings is called a *flight*, especially if the risers are parallel with each other; the steps in this case are *fliers*.

The outward edge of a step is named the *nosing*; if it projects beyond the riser so as to receive a hollow moulding glued under it it is a *moulded nosing*.

A straight edge laid on the nosings represents the angle of the stairs, and is denominated the *line of nosings*.

The raking pieces which support the ends of the steps are called *strings*. The inner one placed against the wall is the *wall string*; the other the *outer string*. If the outer string be cut to miter with the end of the riser it is a *cut and mitered string*; but when the strings are grooved to receive the ends of the treads and risers they are said to be *housed*, and the grooves are termed *housings*.

Stairs in which the outer string of the upper flight stands perpendicularly over that of the lower flight are called *dog-legged stairs*, otherwise *newel stairs*, from the fact of a piece of stuff called a *newel*, being used as the axis of the spiral of the stair; the newel is generally ornamented by turning, or in some other way. The outer strings in such stairs are tenoned into the newel, as also are the first and last risers of the flight.—*Newland*.

Staircase.—A term applied to the whole set of stairs, with the walls supporting the steps, leading from one story to another. The same staircase frequently conducts to the top of the building, and thus consists of as many stories as the building itself.

When the height of the story is considerable, resting places become necessary, which go under the name of *quarter-spaces* and *half-spaces*, according as the passenger has to pass a right angle, or two right angles; that is, as he has to describe a quadrant or a semicircle. In very high stories that admit of sufficient head-room, and where the space allowed for the staircase is confined, the staircase may have two revolutions in the height of one story, which will lessen the height of the steps; but in grand staircases only one revolution can be admitted, the length and breadth of the space on the plan being always proportioned to the height of the building, so as to admit of fixed proportions.

In contriving a grand edifice particular attention must be paid to the situation of the space occupied by the stairs, so as to give them the most easy command of the rooms.

With regard to the lighting of a grand staircase, a skylight, or rather lantern, is the most appropriate; for the light thus admitted is powerful, and the design admits of greater elegance; indeed, where the staircase does not adjoin the exterior walls this is the only method by which light can be admitted.

In small buildings the position of the staircase is indicated by the general distribution of the plan, but in large edifices this is not so obvious, but must at least be determined by considering naturally its connection with other apartments.—*Nicholson.*

Straight Flight of Stairs is one in which the steps are parallel and at right angles to the strings.

Steps (from the Saxon *stæp*).—The degrees of a staircase, by which we rise, consisting of two parts, one horizontal called *treads*, the other vertical called *risers*. When steps are placed around the circumference of a circle, or an ellipse, or any segments of them, they are called *winders*, but when the sides are straight they are called *fliers*. The first, or lower step, with a scroll wrought upon its end, according to the plan of the handrail, is called *the curtail step*.

Stretch-out.—A term applied to a surface that will just cover a body so extended that all its parts are in a plane, or may be made to coincide with a plane.

Scroll or Curtail Step.—The bottom step with the front end shaped to receive the balusters around the scroll of the handrail.

String or String-piece.—That part of a flight of stairs which forms its ceiling or soffit.

String-board.—In wooden stairs the board next the well-hole which receives the ends of the steps; its face follows the direction of the well-hole, whatever the form; when curved it is frequently formed in thicknesses glued together, though sometimes it is got out of the solid like a handrail.

String-board.—In wooden stairs, a board placed next to the well-hole, and terminating the ends of the steps. The face of string-boards follows the direction of the well-hole, whether it be prismatic or an inverted cone. String-boards are sometimes glued in several thicknesses with the fibers of the wood running in the direction of the steps; sometimes they are wrought out of solid, like a handrail, the grain of the wood being in the same direction; and they are also glued up like columns, viz., having the fibers vertical. Brackets are most frequently placed upon the string-boards and mitered into the risers.—*Nicholson*.

Tangent.—In *geometry*, a right line perpendicularly raised on the extremity of a radius, which touches

a circle so that it would never cut it, although indefinitely produced, or in other words, it would never come within its circumference.

Step.—The horizontal board on which we tread.

Soffit.—The under side of an arch or moulding.

Tread.—The horizontal distance between the risers—one of the equal divisions into which the flight is divided; the top of the step.

Wall String.—The board placed against the wall to receive the ends of the step.

Well.—The place occupied by the flight of stairs. The space left beyond the ends of the steps is called the well-hole.

Well Staircase.—A winding staircase of ascent or descent, to different parts of a building, so called from the walls inclosing it resembling a well; called frequently a geometrical staircase.

Winders.—Stairs, steps not parallel to each other.

The winders are supported by rough pieces called *bearers*, wedged into the wall and secured to the strings.

When the front string is ornamented with brackets it is called a *bracketed stair*.

Treads of triangular form used to turn an angle or go round a curve.

Wreath.—The whole of a heliacally curved handrail.

Wreath Piece.—A portion of a wreath less than the whole.

APPENDIX.

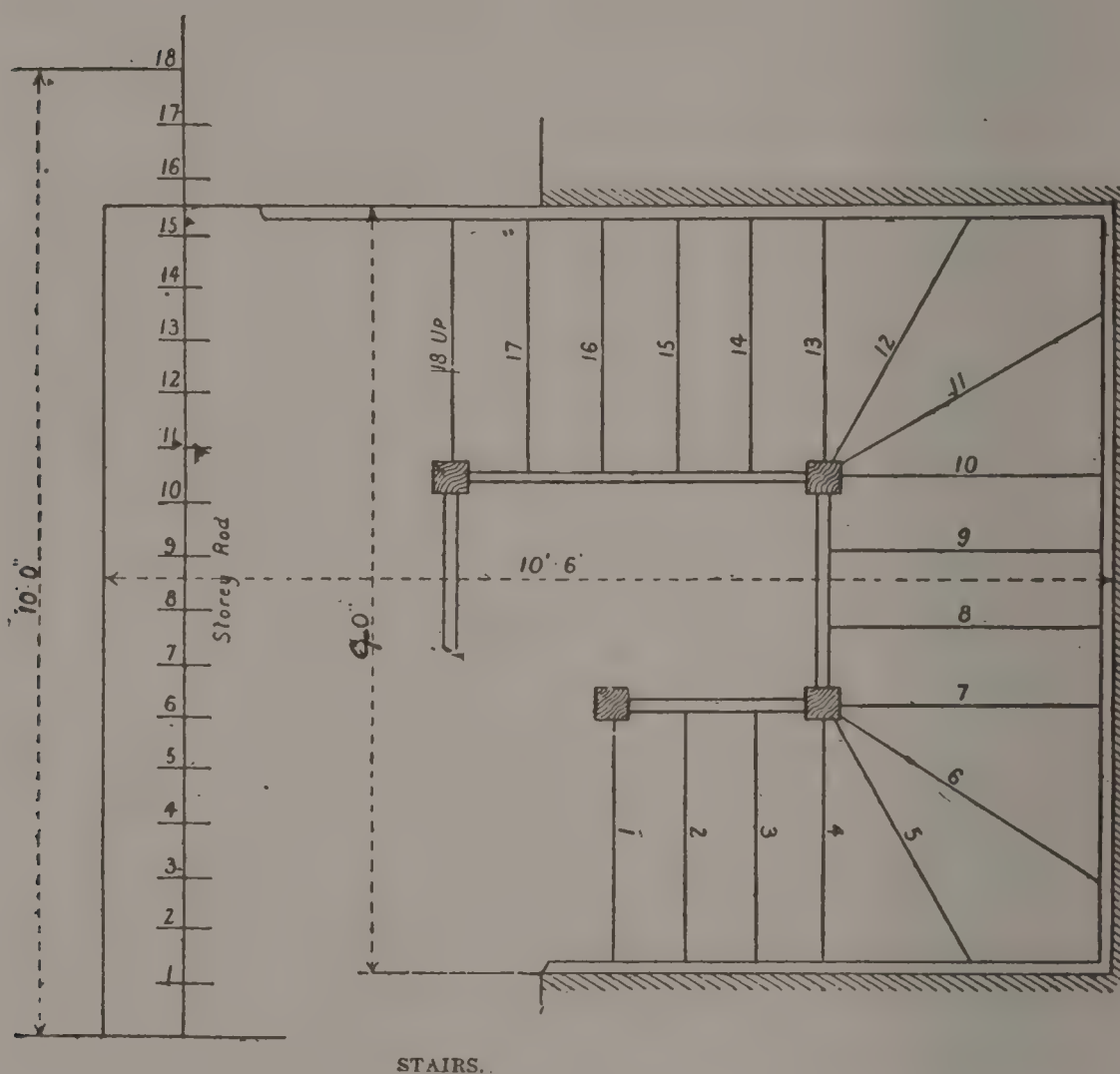
In order to make this book as useful as possible, it was thought advisable to introduce into its columns a few extra examples of "Hand-rail Problems" and their solution from a number of different authorities. This means that the reader will have before him a variety of methods for obtaining like results. Several of the examples shown are worked out by the methods made use of by the late Robert Riddell, who has always been considered the greatest of American Authorities, on Stairbuilding and Handrailing. A number of other examples are shown, in which stairs having irregular plans or elevations and which the workman will find of great assistance, should he ever be brought face to face with one of those difficult problems.

The first example shown, Fig. 1, is a plan for a "newelled" stair in which the positions of four newel-posts are shown, as are also the winders and flyers. The "story rod" with the risers spaced off is shown, on the right of the diagram. Treads and risers are numbered, so the position of each tread and riser is visible. The risers are about 7 inches wide, and the width of the treads is about $10\frac{1}{2}$ inches.

A very simple method of obtaining the bevels for working out a wreath is shown in Fig. 2. No. 1 gives the minimum thickness of plank, which in this case is little more than the thickness of the rail.

"To get the face-mould and bevels, 'drop' lines from the joints on top face of plank A and B, to cut the plan

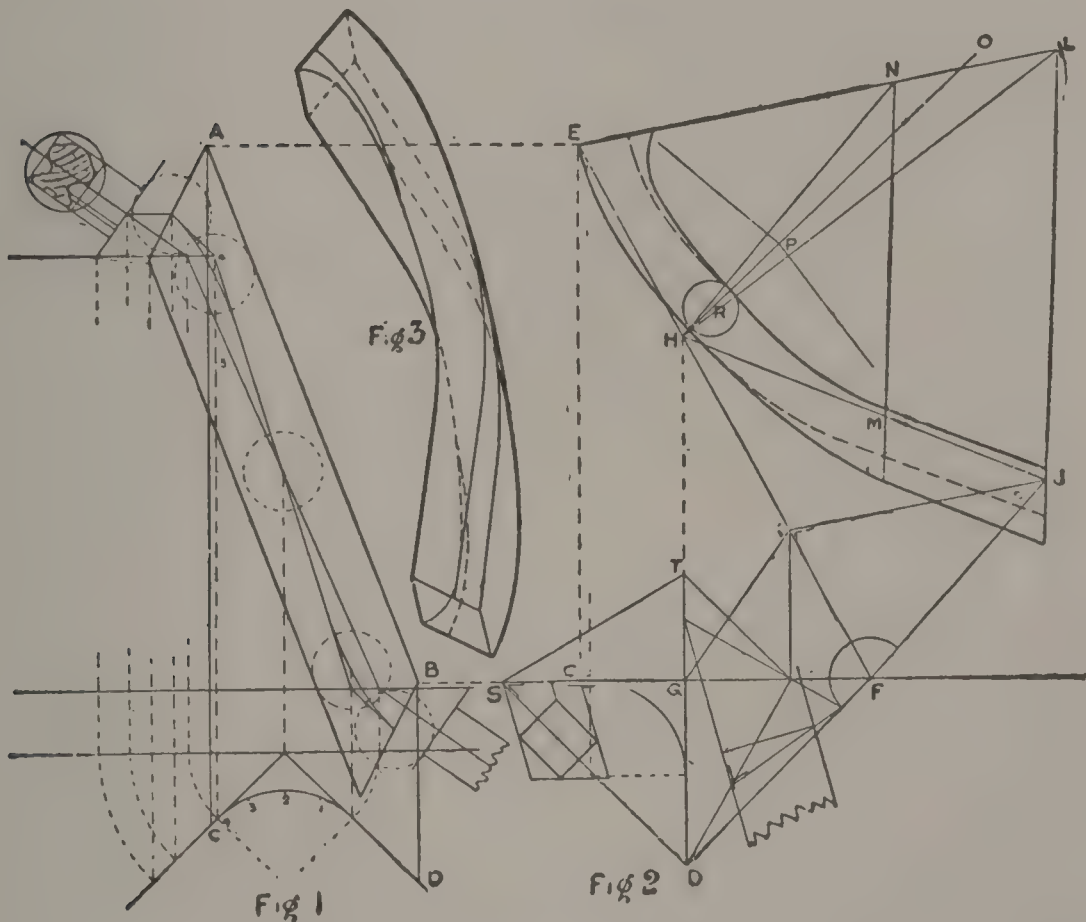
of tangents at C and D, produce a horizontal line from point B to form the ground line in Fig. 2. On this line apply the plan and mark on the tangents points C and D equal to C and D (Fig. 1), at C erect a vertical line to



Example 1.

cut a horizontal line from point A (Fig. 1) at E swing point D on to the X Y line at F. Join E F, which is the falling line of top surface of plank. Project a line from point G to cut in H. Get the tangents in position by making H J and F J equal to H F and F D respectively.

From point G draw a line parallel to joints (Fig. 1) to cut falling line at K. Join K J. Make joints on face-mould equal to angle J K F. Now obtain the position of the arrises at the joints by swinging the vertical trace of joint plane—viz., line G K on to the X Y line at S. Join S and D, which gives the twist bevel on the twist-bevel



Example 2.

line, measure off the position of the center of rail at the joint, as seen in Fig. 1 then apply the rail in the square, as shown, and project the arrises above and below, the projectors being inclined at an angle equal to that made by a vertical plane, intersecting the plane of joint at right angles to the horizontal trace of plane of plank—viz.,

angle T S D. Apply the position of these projections on to the face-mould, those at the top of the joint section for the top joint, E, those at the bottom for the bottom joint J. Produce the joints on face-mould to meet at L, join L H make H M equal to H E, through point, M draw a line parallel to J L, to cut in N, join N H, bisect the angle thus made, viz.—N H L—by line, H O cut off, H P, equal to distance of center of plan to point, G, from point, P, mark the radius of the well to R, at R describe a circle, with a diameter equal to the width of rail, allowing a slight margin for working, mark on each side of the tangent at M the position of the arrises at the lower joint. The curves of the development are got by the very simple process of trammelling, working on the line, H O and the line drawn from point, P, at right angles to H N for upper portion, use line, H O, and the line drawn at right angles to H L for the bottom portion; the curves at the bottom portion are met by lines from the joint, J as shown. This process is purely geometrical, and makes allowance for the easings in the wreath without resorting to the use of intermediate sections.

Fig. 3 shows the application of the face-mould. When you have marked it on the surface of the timber, turn the face-mould over, and apply with the upper joint over the lower joint, overhanging same, as shown, keeping the joints linable, the amount of overhanging being obtained by running the depth of the plank on to the dihedral angle, and then dropping a line from where it intersects the side of the angle, as shown in Fig. 2. This gives the correct position of the joint on the lower face of the plank when the dihedral angle has been applied.

You may now cut out the plank with the band-saw, working on the outside lines.

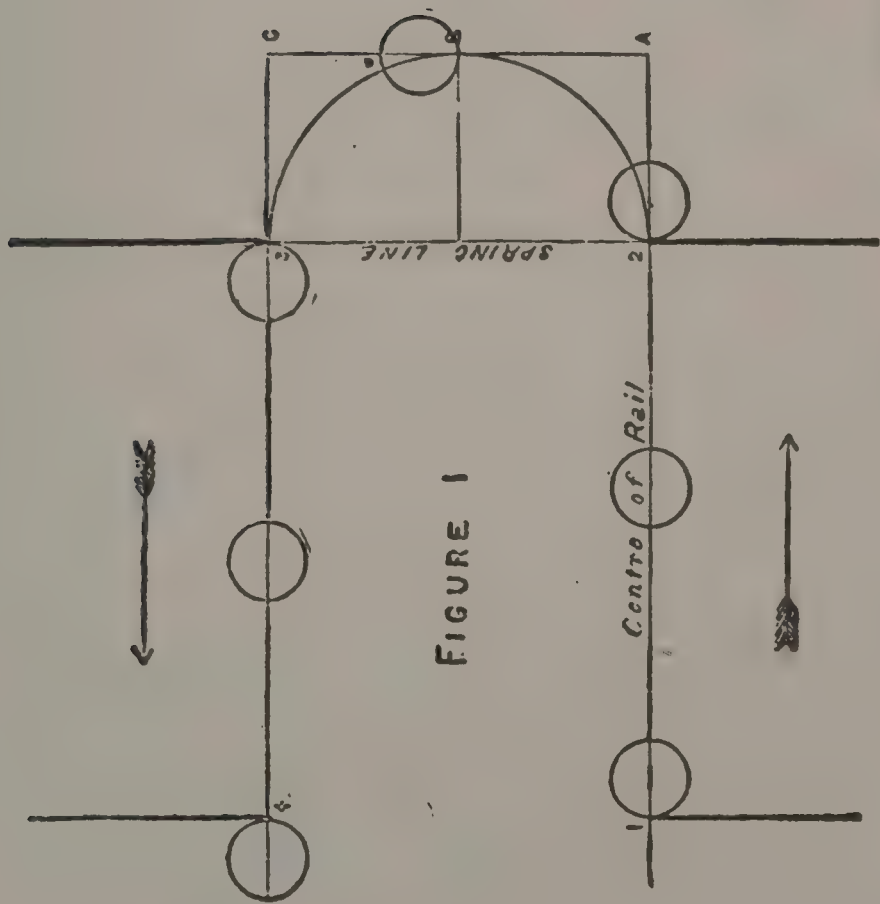


FIGURE 1

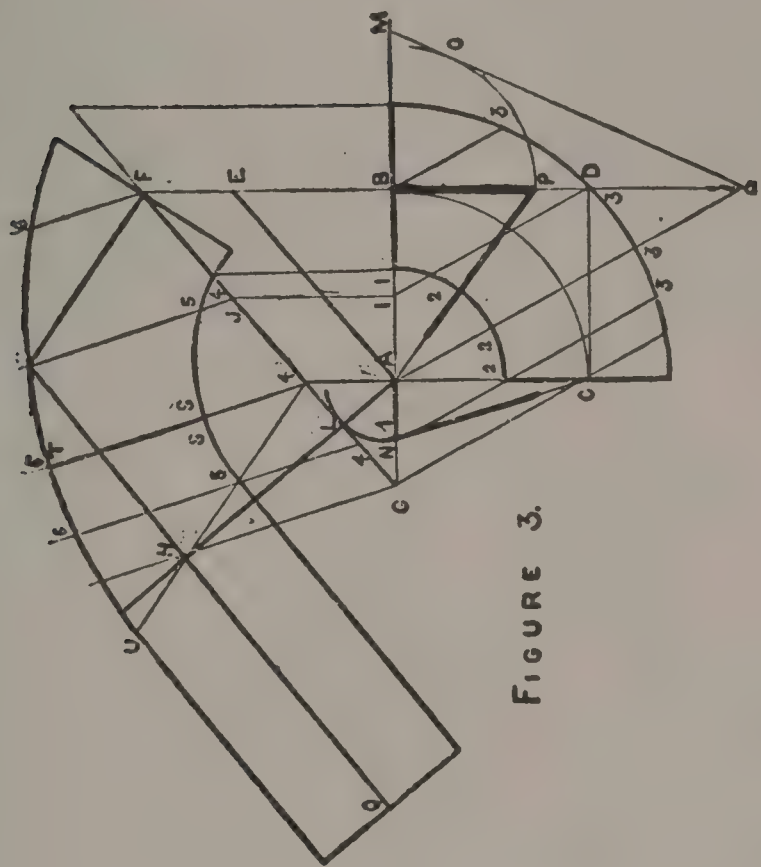


FIGURE 3.

Example 3.

This system has much in its favor, for it not only gives an accurate and graceful result obtainable from the minimum amount of stuff with the use of comparatively few lines, but also gives the workman guiding lines sufficient that he will be able to mould the rail in the same time as would take to mould a wreath without the easings.

WREATH FOR HALF-SPACE LANDING.

To lay out lines and bevels for a half-space landing when the well-hole is less than the width of a tread, we proceed as follows: Fig. 1,—Examples 3 and 4: show the center line of rail and the risers at the spring line. 2A— A, B, C,—and C₃. Fig. 2 (the falling line of the tangent): draw the line 2, A, B, C, 3, equal to 2, A, B, C, 3, at Fig. 1 draw the perpendicular lines A D—B E—C F and 3 G, and make 3 G equal the height of the riser at 3 Fig. 1. Draw 2 D, with the *bottom* pitch-board, draw G to F with the top pitch-board, and draw the straight line D F, Fig. 3 (the face-mould for the bottom wreath). Mark the quarter circle plan of wreath, and the center line B C, make B E and B F equal to A D and B E at Fig. 2 draw A E, draw F G parallel to A E, draw G C; draw A H square to A E from G with the length G C cut the line A H at H, and draw G H. Draw ordinates 1, 2, 3 at any convenient distance apart, parallel to G C, draw the perpendicular lines 1, 4, and draw the lines 4, 5, 6 parallel to G H; apply the lengths 1, 2, 3, to 4 5 6, and draw the face mould through the points 5, 6. Apply the ordinate I D from J to K and draw the tangents K H and K F, make the shank H Q about 9 in. long; make the joints square to the tangents; draw 4 H U and make

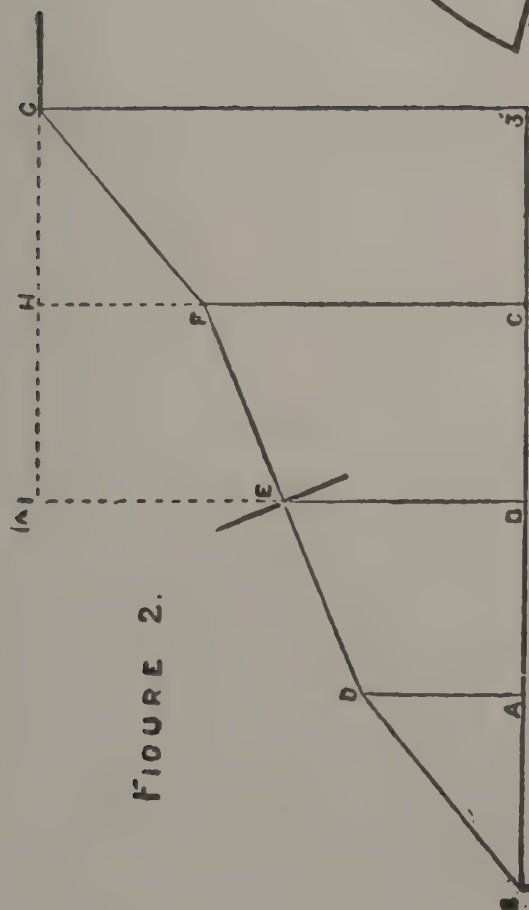


Figure 2.

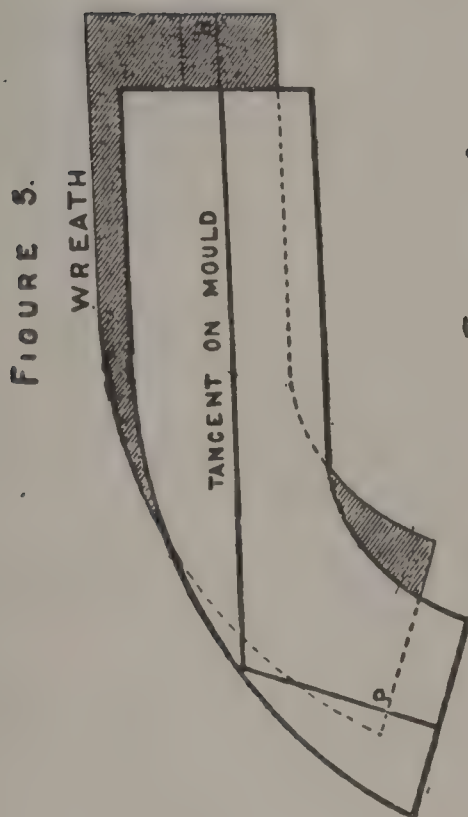


FIGURE 3.

Figure 4

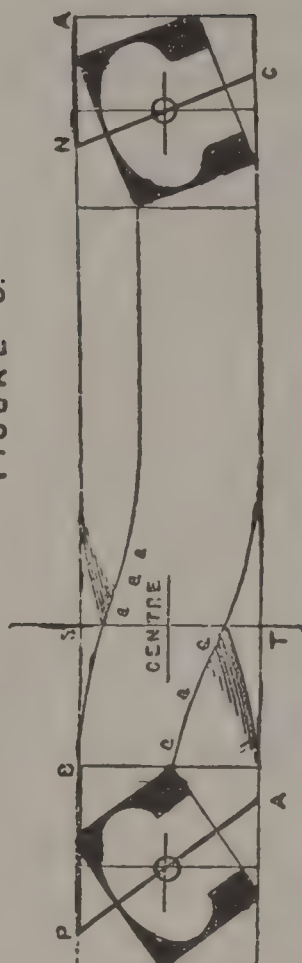


FIGURE 6.

Example 4.

H U equal H 5, and from 5 and U draw the shank parallel to the tangents. From A describe the arc L N and draw N C, and A N C is the bevel for the bottom end; make B M equal B E, draw out the lines A 3 and B D to meet at R, draw M R, from B describe the arc O P, and draw P A and B P A is the level for the top end.

NOTE.—In drawing the face-mould for the top wreath the heights of B E and B F, at Fig. 3, must be equal to H F and I E at Fig. 2; that is, supposing the top flight is a different pitch to the bottom flight; but when both flights are the same pitch, or very nearly so, it is not necessary to draw Fig. 2; as B F at Fig. 3, would be made equal to half a riser, and the lines A E and F G drawn with the pitch-board, and one face-mould does for both wreaths.

To Square the Wreaths.—1st. Cut them out square, and a little full in the narrow part, and join the ends square; mark the tangents on both sides of the mould, and also on the top side of the wreath, and then square them over to the underside of wreath. 2nd. Center the joints, take the bevel A N C at Fig. 3, and apply it through the center of the bottom joint, and mark the square section of rail, as shown at Fig. 6; take the bevel B P A at Fig. 3, and apply it through the center of the top joint, and mark the square section of rail. 3rd. On the top of the wreath, from the joints N and P, at Fig. 6 (where the bevels come to the top of the wreath-piece), draw parallel lines to the tangents, as at N N and P P, at Fig. 4; and on the underside from the points A and C, at Fig. 6, draw parallel lines to the tangents. Apply the face-mould on the top of the wreath, and slide it over the top joint until the tangents on the mould are over the parallel lines on the wreath, as shown at Fig. 5, and mark

it; apply the mould on the underside, and slide it over the bottom joint until the tangents on the mould are over the parallel lines on the wreath and mark it. 4th. Set a pair of callipers to the width of the rail, and move one arm along the marks on the top and bottom of the wreath made by the outside of the face-mould, and the other arm will mark, very nearly, what to take from the inside of the wreath, as at a, a, a, Fig. 6. Work the inside with a round plane that fits the curve, 2, 2, 2, Fig. 3, in a skew direction to the marks on the top and bottom of the wreath and the bevels at the ends, and gauge the shank part parallel to the top. Gauge the outside from the inside with the callipers, and gauge the shank part parallel to the top. To work the top, gauge the shank part parallel to the top of wreath piece, and at the part S T, at Fig. 3 (which in every case is the part where the ordinate, 4, 5, 6, from the center A, crosses the mould), take an equal portion off the top and bottom, both inside and outside, as shown at S T, at Fig. 6, and work it twisted to the bevels at the end. Gauge the underside from the top side. The top wreath is worked to the same hand as the bottom one, and turned over before dowelling or moulding.

HANDRAIL FOR QUARTER CIRCLE.

Stairs having a level landing or platform are among the most numerous examples and are frequently among the first style of stairs the young workman is confronted with, and it is therefore essential he should make himself familiar with the methods employed for finding the lines and bevels, for laying out the work so that no trouble will arise in putting the work together. The

method shown in Plate 1, is a good one and not difficult to master. Fig. 1, Plate 1 is the plan of stairs having a quarter circle at the landing and the starting. Stairs of this description are exceedingly simple in their construction, the only point requiring particular attention is in laying down a correct plan to work by, and in having the last riser landing and the first starting, in such a position on the plan as to cause the level rail to stand at a proper height above the floor, so that the landing wreath, if reversed, will answer equally well for starting. Neglect in this arrangement of risers will render it impossible to have the wreaths present anything like lines of either grace or beauty.

Fig. 2 shows the elevation. The square sections of rail are marked so that their under sides stand half a riser above the floor. To determine the position of riser starting: From N draw the pitch of stairs; make B K equal the height of a riser; from K square over a line, cutting in T, thus fixing T A as the face of riser starting, and giving B A as a distance, which is transferred to plan as shown. To find the position of riser landing, draw from L the pitch of stairs. Set off the thickness of rail D J; extend the floor line, cutting the underside of rail in D; this gives C D as a distance, which transfer to plan, thus showing the position of riser landing.

The proper cut for carriages and width of trimmer, being given; proceed to find a mould for the wreath by applying the pitch-board as shown. Set off half width of rail on each side of the perpendicular, as 2 B and 3 C; have a piece of board as shown at Fig. 3, and on its surface run a gauge line, say three or four inches from its edge. From any point, A, square over a line; make A 2 3 equal to P 2 3 on the base of pitch-board and A B C to

equal corresponding letters shown on the long side of pitch-board. Now find points for pins, and sweep the elliptic curves with a string which completes the mould.

Fig. 4 gives an idea of the manner in which the slabs are cut off the landing piece of the wreath. The thickness of rail on the straight wood, is gauged from the top surface of the plank, and at the upper part which forms a portion of the level rail on the landing. Here let the upper slab be cut off square with the joint, then the corner of the concave side forms a gentle and easy curve from the rake to level part of the wreath landing. The same piece of wreath, by reversing it, answers for the starting, which shows the advantage of having risers on the plan in a proper position.

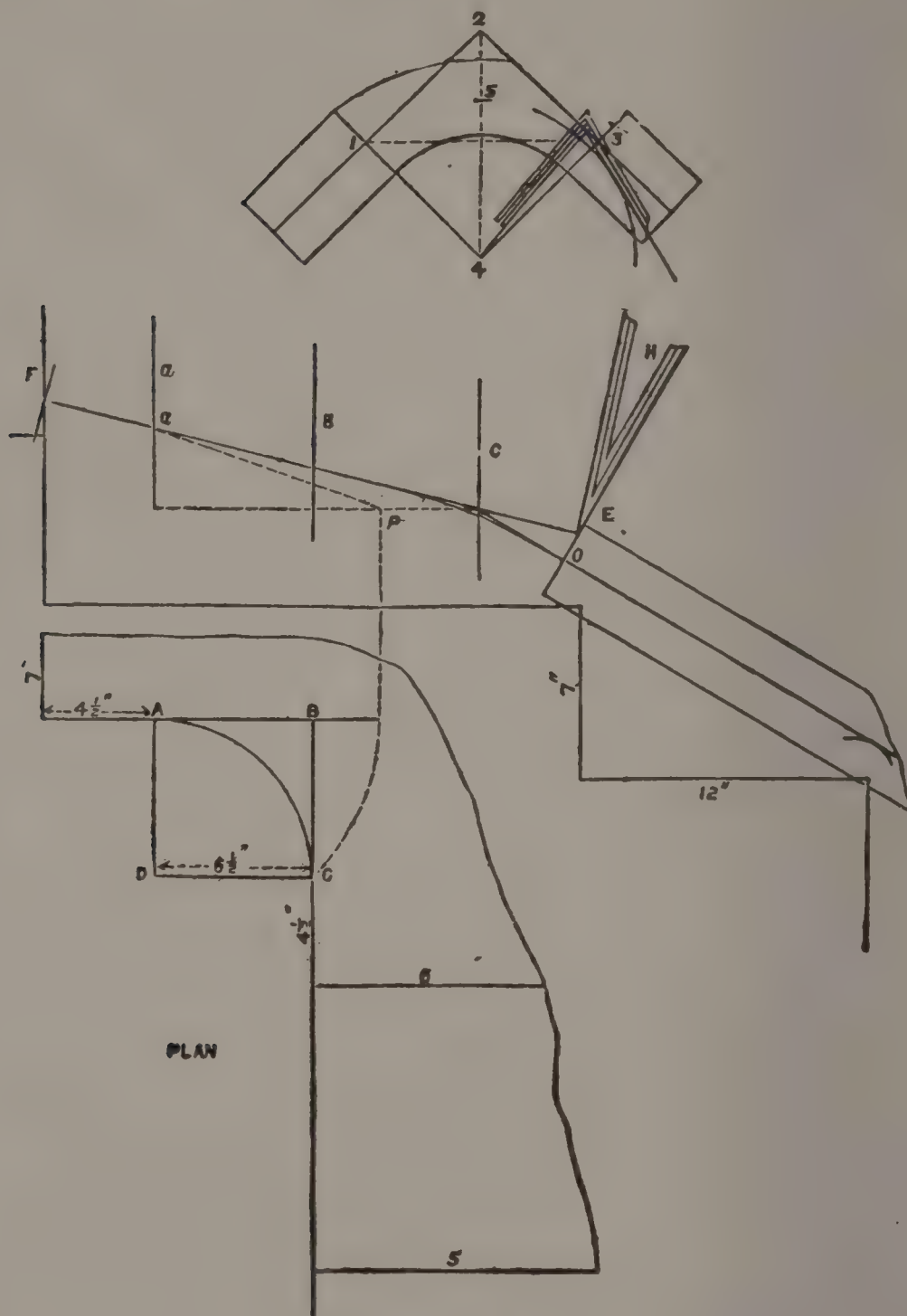
In applying the mould to mark the plank, see that the grain of wood is equally divided in the wreath. As a general rule the width of a rail, and the thickness of plank for wreaths, are equal. In other words, if the hand rail is four inches wide, it will require plank four inches thick for the wreaths. Another point for the learner to remember, is to have one surface of the plank for every piece of wreath, made perfectly true and out of wind, in order that bevels may be properly applied.

The importance of this cannot be over estimated. Even a greater degree of nicety should be observed than in preparing mortises, tenons and shoulders for any description of framing requiring exact fitting.

WREATH FOR QUARTER-SPACE.

Let A B C D, Example 5, be the quarter for lower piece. At any convenient point above plan set off two equal spaces equal to A B; now locate the fifth, sixth, and seventh risers, locate the center of short baluster and set

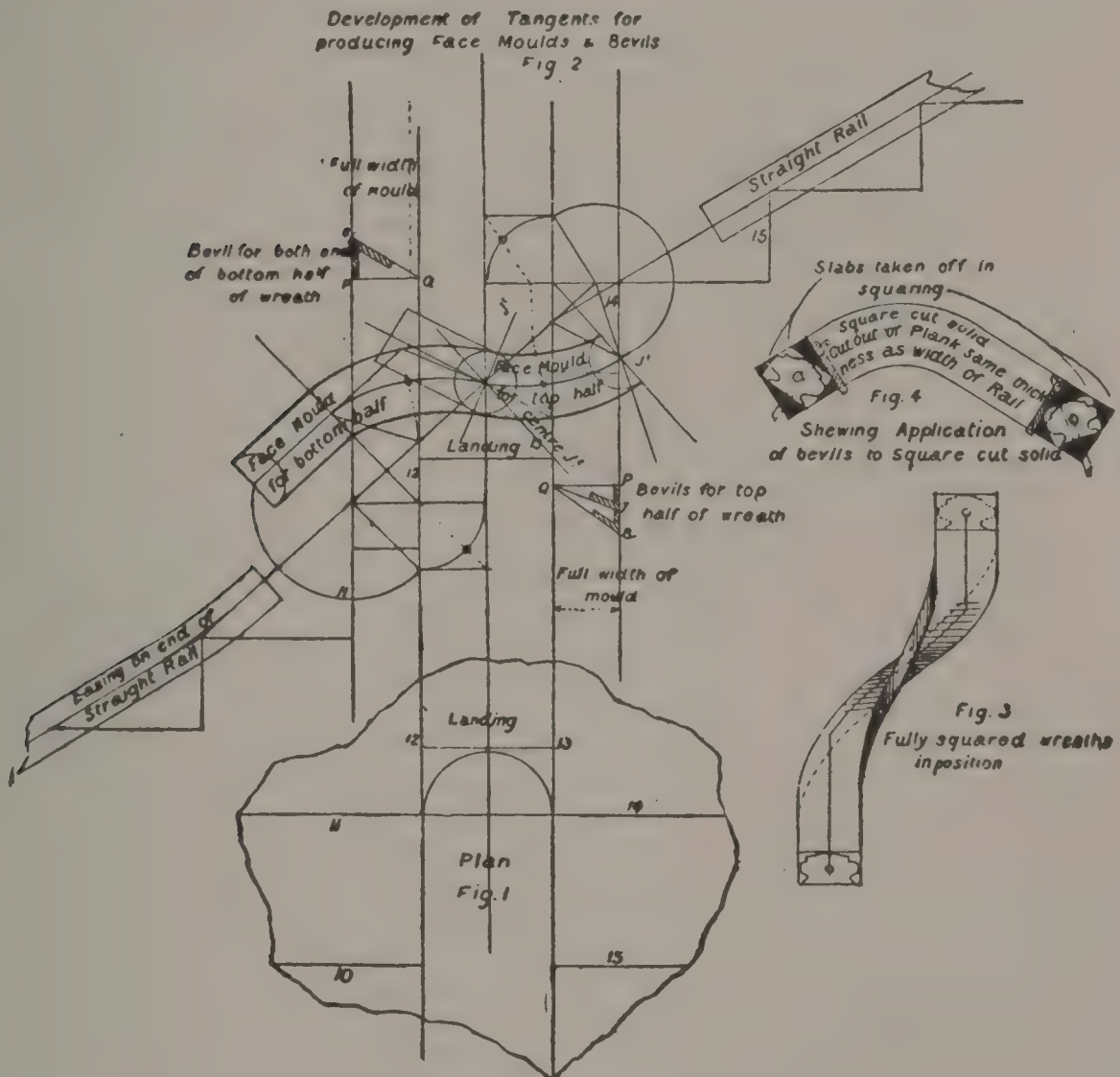
off half thickness of rail; draw to cut chord line, E; now draw the tangents through A B C produced to E, then



Example 5.

E O will be the extra thickness required for the twist, To draw the mould, with A as center, A C as radius, de-

scribe dotted line, draw to cut dotted line at P, from P draw to *a*; this will be the major length of mould. Make 1 3 equal to *a* P, 1 2 and 2 3 equal to *a* B, produce 4 in the same manner. With P A as radius and center 4, describe



Example 6.

an arc at 3, square from tangent to 4, when the line touches the tangent draw, touching the curve; that will give the bevel for all the joints for center of rail. Take A B on plan, place it from 4 to 5, set off on each side of the half thickness of rail, find width of ends by the bevel,

draw the curve with trammel, make joints to face mould square with face of plank, now dress out the inside, apply bevel H to the butt joint.

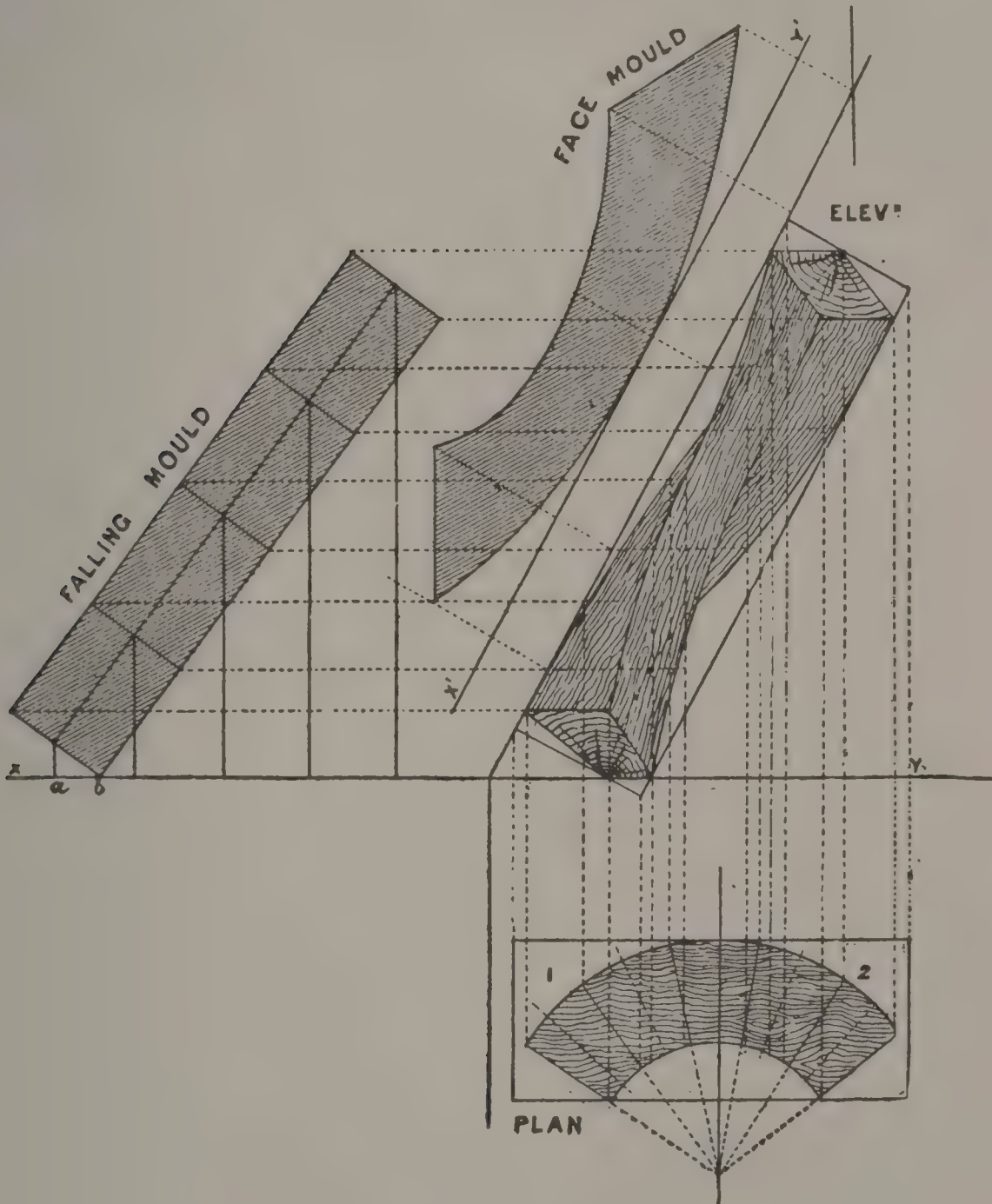
HALFSPACE-STAIRS.

A 9 in. well, with balusters $1\frac{1}{2}$ in. square, would mean $10\frac{1}{2}$ in. from center to center of rail, so proceed as follows: Draw center line of quadrant, Fig. 6 and enclose it as usual, 1, 2, 3, 4; also one riser at the springing, and tread ten. Draw center pitch of straight rail on edge of riser, X. Fix position of shank joint about 8 in. from springing, and draw in the joint, Y, on straight rail at right angles to pitch-board. Continue line 3, 2 above landing half a riser to O. Draw line from Y to O, which is center pitch of plank. The bevel, Y A R, from top side of plank, through the center, which requires the face-mould to be left $\frac{1}{4}$ in. longer in practice as before, but must be carefully compared. Fig. 4 shows how to apply bevels to square out solid. If he thinks the easing, X Y, is too flat, he can bring it up nearer the springing; but the center tangent will be steeper, and the wreath shank shorter.

A SPIRAL STAIRCASE.

In Example 7 a spiral staircase is represented by a plan and elevation of rail. The determining of the projections is simply a case of the accurate representation of points and lines and is good exercise for the student. A stair of this kind may be of stone, timber, or iron. If of timber, the strings are usually built up of breadths suitable for

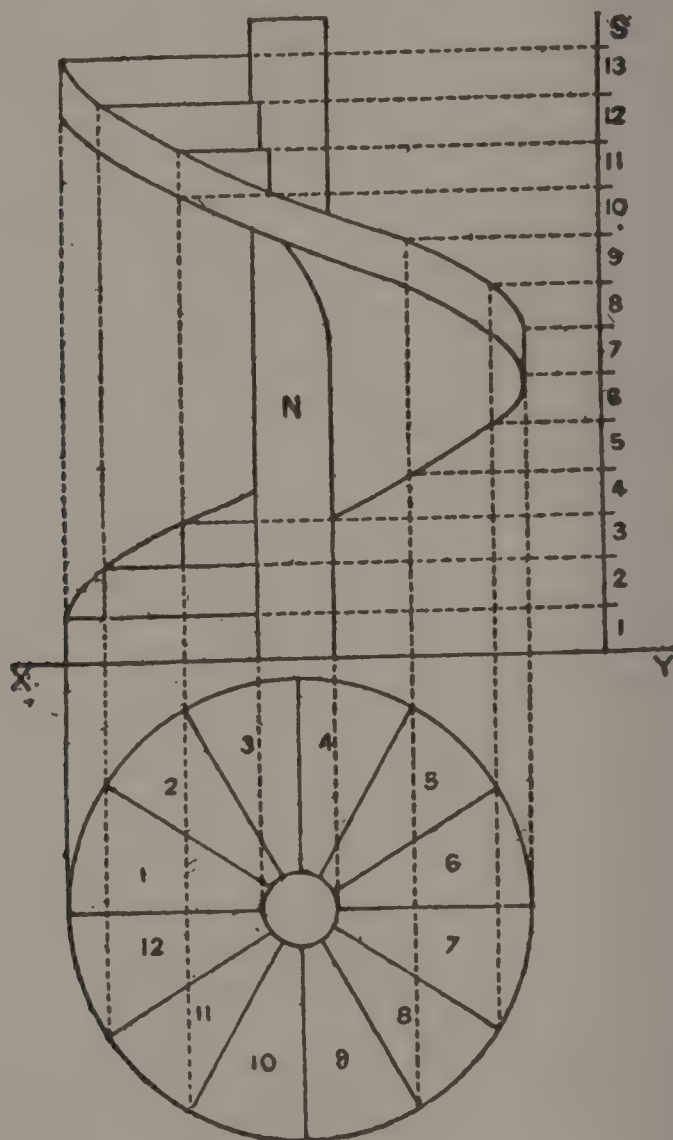
the ends of the steps at the height of the risers. They are jointed vertically, and the lines of the joint coincide



Example 7.

with those of the risers on plan. In this example no inside string is used, the steps being carried by a newel post. When made of iron or other flexible material, the

strings are in one piece and the cylinders, of which they are portions, require to be developed in order to ascertain their true lengths and bevels. In the diagram S is the story rod.



Example 8.

When a stair is built as shown by the part plan in Example 7, it is called a geometrical staircase. The steps consist of flyers and winders, and the strings are partly straight and curved. The chief difficulty in setting out a stair of this kind is to know how much to diminish the

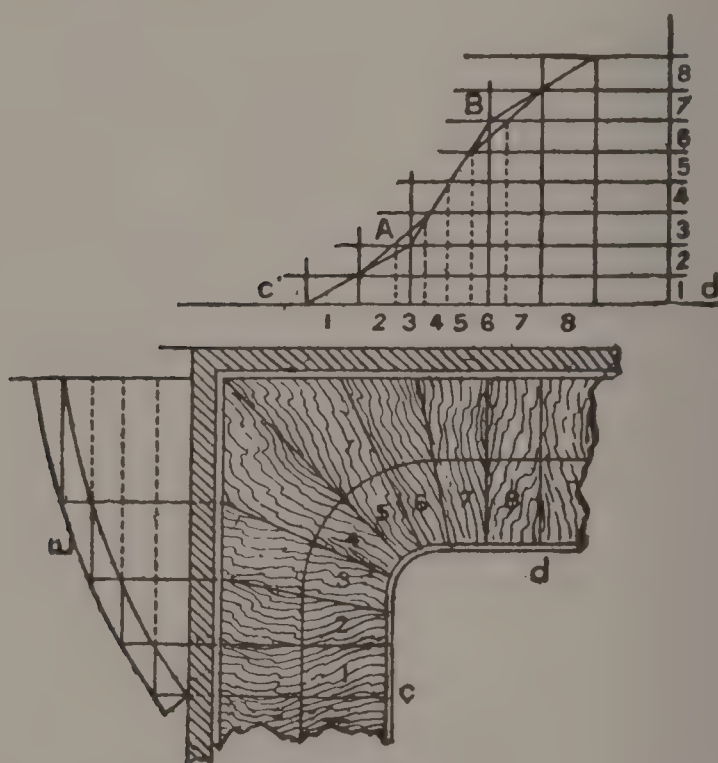
APPENDIX

winders at the narrow ends, so as to produce a regular curve on the soffit or underside. This can readily be ascertained by developing the curved string containing the ends of the winders, and also as much of the straight string on each side of it as will contain two or three flyers. On setting out this development, as Example 7, in the diagram, it will be seen to form an unsightly angular soffit at the extreme points. These points are then remedied to taste by drawing regular curves in them. The points in which these curves intersect the horizontal lines of the risers on being projected will give the required breadths or diminishings of the steps. These are then transferred to the plan. This is very clearly explained in Newland's "Joiner's Assistant," and it is very singular that it is not universally adopted, as it is the only exact manner in which a good soffit can be determined. At E an elevation of one outside string is shown. All the rest can be projected similarly. In all stairs containing flyers and winders a center line is employed on which the divisions for the steps are made uniform throughout, as at 1, 2, 3, 4 &c. Geometrical stairs take up less room than square landing ones; but they are not so easy of ascent and descent, and they are also much more difficult to handrail, especially when built without newel posts.

Stair-railing is a subject of so much abstruseness and diversity of opinion that we will not here enter into any particular details respecting it. It is a subject with which geometry cannot deal with that degree of accuracy of which other investigations are capable, and consequently will be an everlasting source of controversy; though, no doubt, properly applied, geometrical constructions give very exact approximations. We will only consider here how far elementary geometry can be brought to bear up-

on it, so that the general student may have a chance of at least investigating the properties and peculiarities of a wreath. After that he can if he chooses, study the various methods usually employed in practice.

In Example 9, the plan and elevation of a wreath for a quarter having the steps equal are given. A central section of the wreath, as at 1 2, is first drawn on plan with its extremities equidistant from the vertical plane. Then



Example 9.

the outside falling-mould is set off, making it equal in breadth to the thickness of the rail. The line, *a b* on *x y*, shows approximately the projection of half the wreath on plan, and, accordingly, from *a b*, complete the plan. The elevation is now drawn from the plan and the falling-mould, and the projections of the plank required drawn tangent to those of the wreath, as shown. The face-mould is a section of the cylindric surfaces by a plan through

the center of a plank, as 1 2, or a parallel to it. When applying it, the points to which its corners are kept are easily obtained from the projections of the plank. By cutting the ends of the plank through at these points, the joints are determined. It is very convenient when drawing these points on the plank to construct it into the horizontal plane. The working for this is not shown on the diagram, but it ought to be readily understood, as the four points to which the mould is kept on each face of the plank are shown on the projections. An inside falling-mould may be used if great accuracy be required.

SHOWING QUARTER LANDING STAIRS.

Fig. 1, Plate 2, shows the center line of rail struck with a radius of eight inches. The face of risers on the plan are opposite. The whole height of a wreath for these stairs is equal to three risers, that is to say, by counting from the top of step D on the right, to top of riser on the left. The mould for this wreath is found by making 2 3 equal one riser and a half, and P R equal to D N; apply the pitch-board and draw the line R C B A; continue the center lines of rail, cutting in L; join A L and B D; this gives C B and B D as the pitches of tangents in one-half the wreath.

Fig. 2 shows a piece of board. Draw any line on its surface, as A B C which is equal to corresponding letters on the pitch-board; from A B as centers with A L and B D on plan for radius, make the intersection in L; join L B and L A, which shows L B C as the angle of tangents on the mould. To find the short diameter, let C D equal B A; through D draw parallel with A L—make

D 3 equal A L; through 3 draw the long diameter square with 3 D; draw the joint through L square with L B—make 3 D equal the radius 3 D on plan. The width of mould at each end is determined by having joint bevels. These are found by taking 3 as center, and from it strike an arc touching line B C; with same radius and D as center, intersect the long diameter in J; join it and D; this gives bevel J for joint on straight wood. Again take 3 as center, and from it strike arc touching line L B; with same radius and D as center, make the intersection in F—join it and D; this gives bevel F for center joint at L; half the width of rail being set off above the long diameter, cuts both bevels and gives half the width of mould on each to set off on each side of L and V; draw the straight wood parallel with C V; now find points for pins and strike the elliptic curves with a string, which completes the mould.

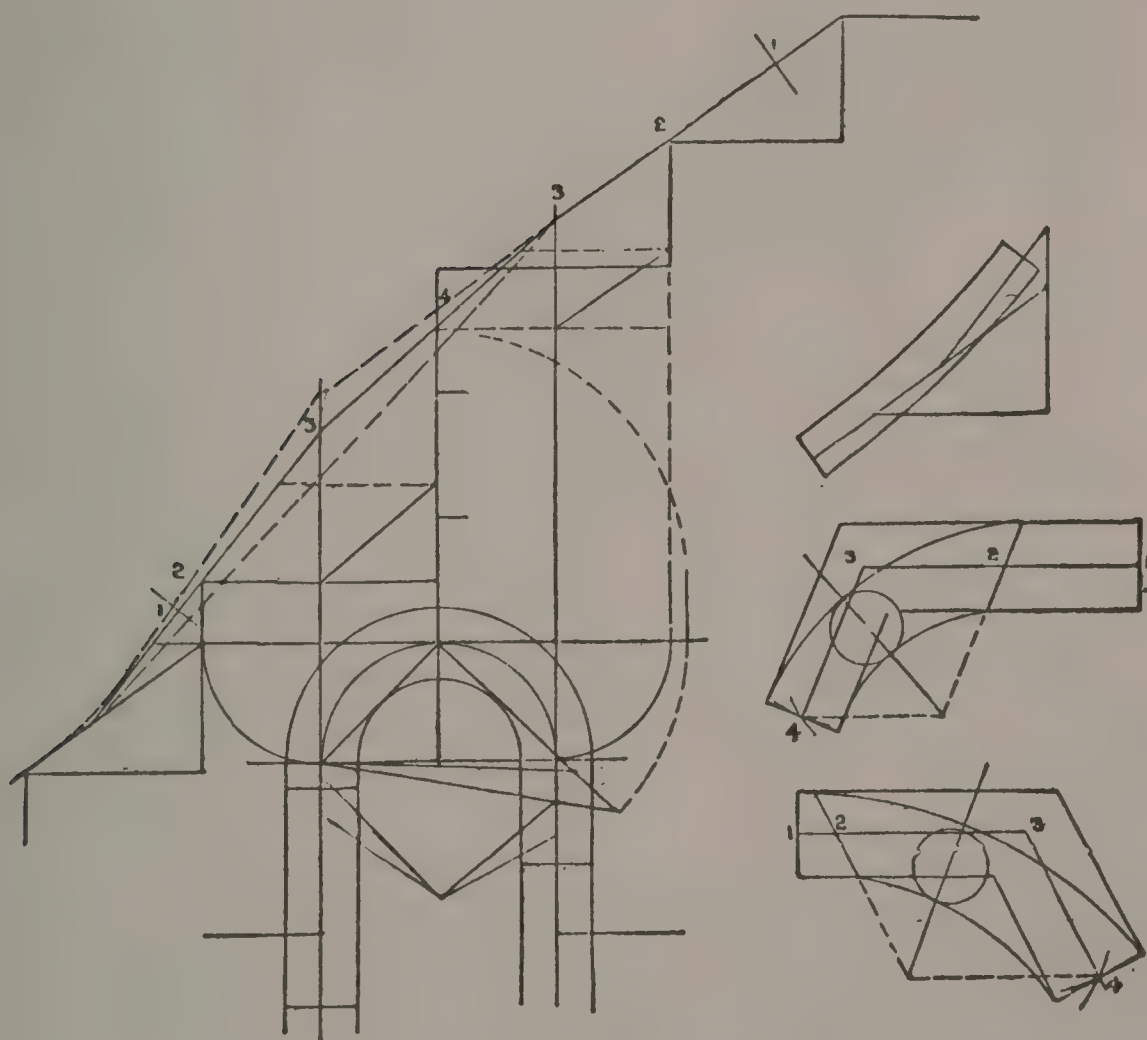
Fig. 3 gives an idea for cutting the plank square through. The square sections of rail show the application of joint bevels.

Fig. 4 shows a method of finding the long diameter of a semi-ellipse. Let the angles L B C and 3 D equal those of Fig. 2; from L as center, with a radius equal to 3 D on plan, intersect the long diameter in 2; draw from L, through 2, cutting the short diameter at 3; this gives L 3 as half the long diameter of a semi-ellipse in the center of mould, but this, in practice, is not required at all times; now proceed by making 3 K equal L 3; join K D; set off half width of rail on the perpendicular through K, and through points thus given, draw parallel with D K cutting in P and R; this gives 3 P for the inside; and 3 R for the outside curves on the mould.

Fig. 5 shows the cuts of carriages, landing and starting.

QUARTER SPACE WITH WINDERS.

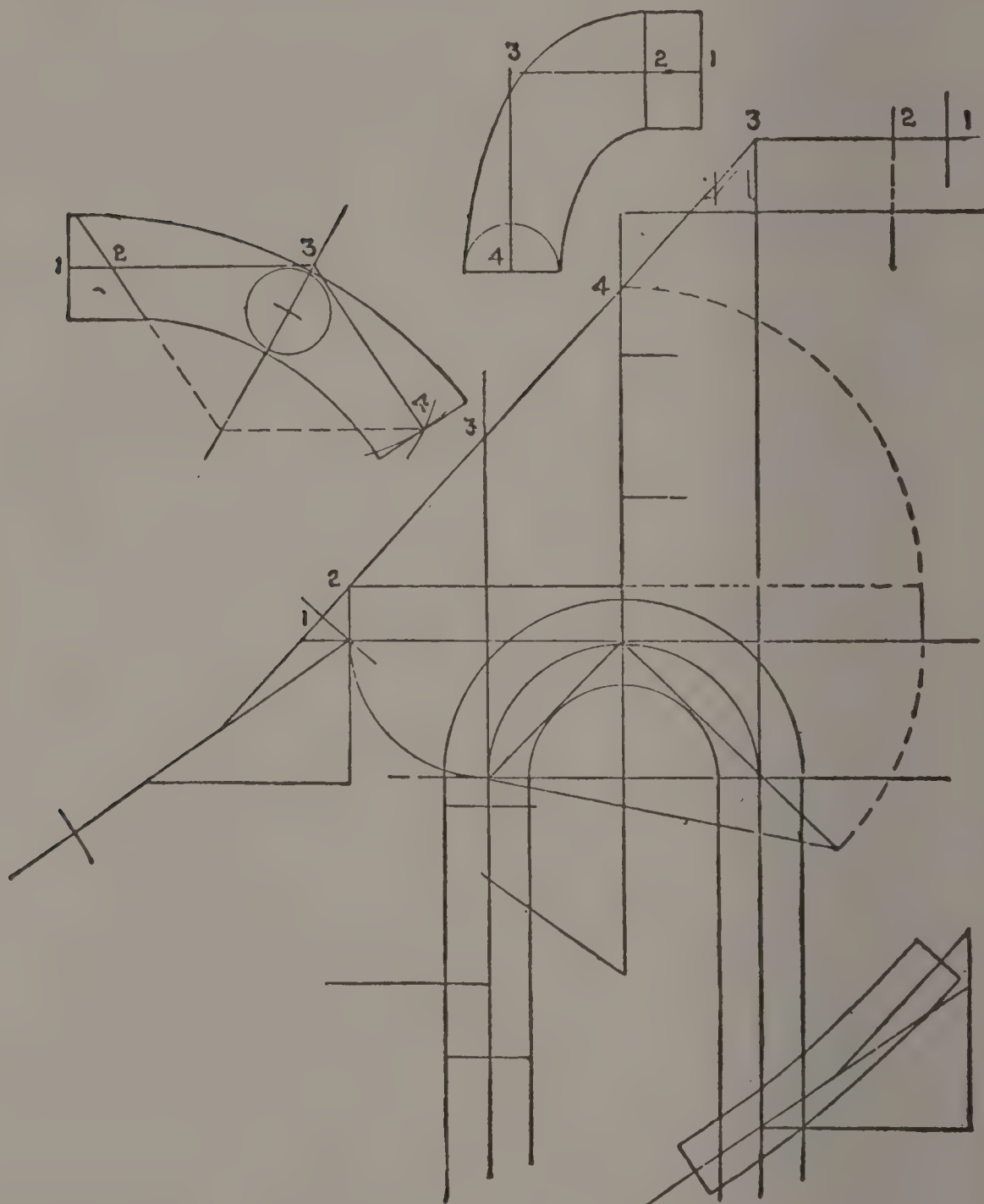
The two examples shown at Figs. 10 and 11 are rather out of the usual way. No. 11 is a rail for stair with three winders in one quarter and the other quarter level on a



Example 10.

platform. Set up three risers on the center line, stretch out the square, apply the pitch-board at the springing lines, both top and bottom. To get the best pitch for wreath, extend the top pitch to point 3, on the left, as shown by dotted line as a ramp will be required, fix on

a joint on top edge of pitch board, far enough down to afford a good easing, and from it draw dotted line to



Example 11.

point 3, on the right. Now, either of these pitches can be used, and the lower one is generally used, but the

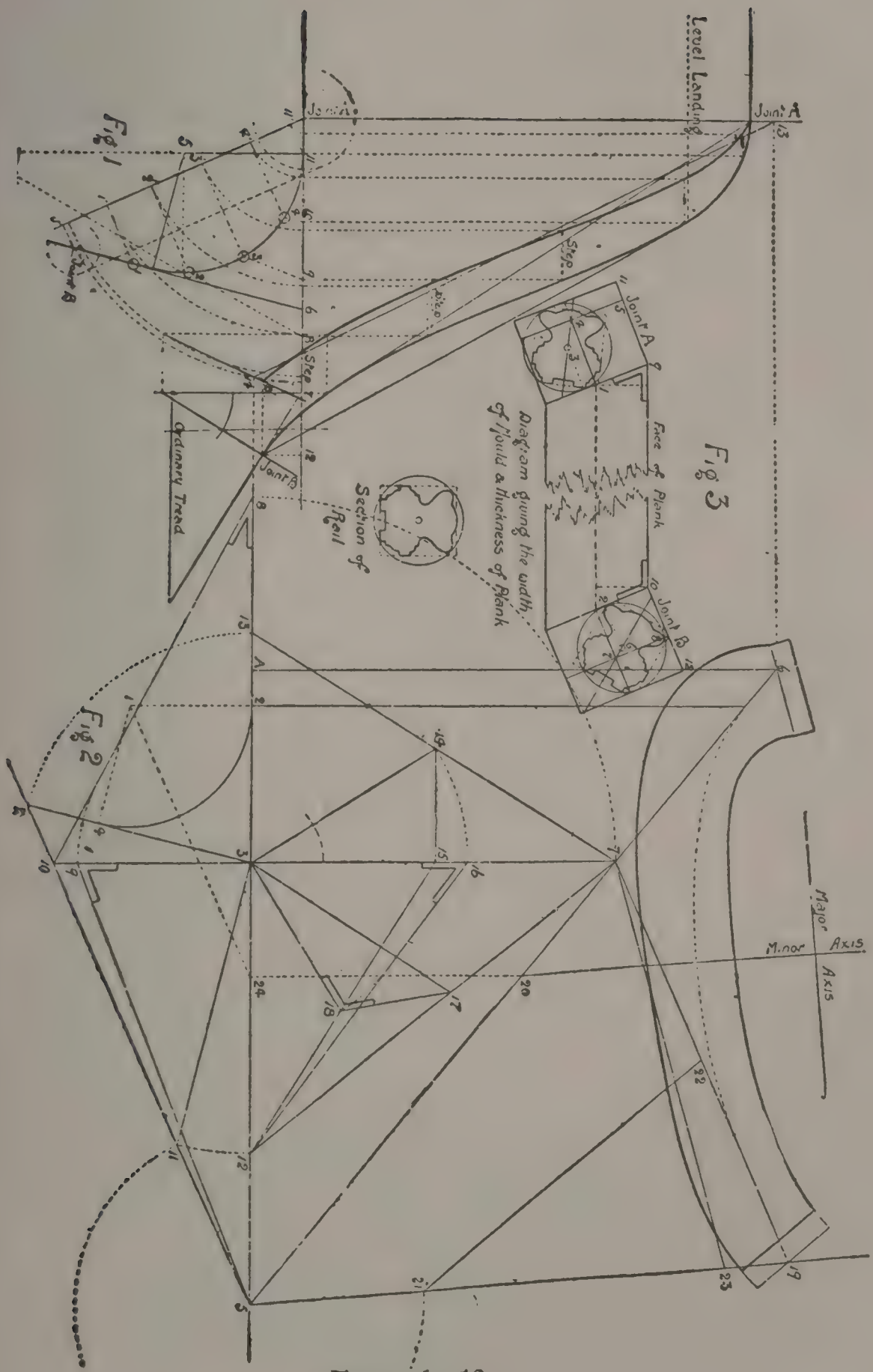
top one is not high enough at the point, 4, and is too high at 3; the bottom one is still lower at the point, 4, and likewise a little low at the point, 3, so a middle course is adopted and the pitches drawn. By drawing a line parallel to the two pitch lines, 3 4, on the left and 2 3 on the right, and squaring over a line from the top point of each, as shown by dotted lines, to cut the pitch lines, locate a point on them, giving a third point in the curve through which to bend the strip when drawing face-mould as was shown and explained when given in diagram of block with Nos. 3 and 4. The face-moulds are drawn exactly the same as before, with the addition of this third point; it is transferred from the elevation, and set off on the face-mould, the same distance from the point 3, on the corresponding pitch line. A line is then drawn through it from the intersection of the springing lines, as shown. Then with the compass set to the ground plan of the rail, both inside and out, mark from the intersection the inside and outside of rail, as shown by the circles on face-mould, and bend the flexible strip through the three points and lay in the curves. We have supposed the risers to be in the quarter circle, as it is there they are generally found by the handrailer; but if he builds the stairs the risers would be placed to suit the elevation. The landing riser would be where the upper pitch cuts the landing, and the riser starting the winders would be where the lower pitch strikes it, just below the point 1, which is nearly three inches outside the springing line, and the winders divided equally between these two points. The ramp is drawn from pitch-board, and set up to equal the distance from top point to 2 on the elevation. Block gives bevels, and these are drawn across rail as shown on plan, giving widths of ends of face-

mould. No. 11 is a rail for stair, with three winders in one quarter and landing on the level. Set up three risers on center line, stretch out the square on the left, and apply pitch-board at the springing line. Set up the height of level rail on the right, and draw center line to point, 3. Now draw pitch over winders from point, 3, to a point on top edge of pitch-board, far enough down to give a good easing. The face-moulds are drawn in the usual manner, bevels are taken from block. If hand-railer builds stairs, the risers would be arranged in the same manner as in number 10. The ramp is drawn same as in No. 10. The bevel for the upper part of wreath is shown below the point, 3, on the right, and shows the half width of face-mould at shank end, the other end at 4 being the exact width of rail.

A SIMPLE METHOD.

Though not following any orthodox method the diagram shown in Example 12 is an attempt to lay down handrailing, so as to appeal to the intelligence of all those who would aspire to become proficient in this most beautiful art. All that is necessary is a sincere desire for the knowledge and a willingness to give that quiet concentration that the subject demands.

With a view to include as many of those features that are generally looked upon as difficulties, we have taken a rather uncommon example. But if the reader will bear in mind what we have said before, and carefully follow the description, he will find that these supposed difficulties are non-existent. By taking each process separately and giving his whole attention to it until he is satisfied that



Example 12.

he has grasped the true meaning he will thus arrive at a correct impression of the whole.

We have purposely abbreviated the explanation in order to bring into full activity the readers' intuitional resources.

The plan as seen in Fig. 1 is for an acute well, having risers placed as indicated by the small circles, 1 2 3 4, finishing on a level landing.

It is intended that the wreath shall include the easings both at the top and the bottom, so that the joints shall be square to the straight rail in either case.

Having drawn the plan proceed to get the development of the well by using the sixty degrees set square, cutting the quadrant, extend the line until it intersects the other radius produced. By drawing lines from this point, cutting through the several points on the plan, and producing same until they meet the $x y$ line, you will obtain points 10, 9, 8, 7. At point 8 erect the height of one riser, at point 9 two risers, at point 10 three risers. This will get you to the height of the level landing. The rail must now be lifted up an extra half a riser to accommodate the additional height required for the rail on the level. We are now able to draw the central falling line of rail, which must be graceful and at the same time coincide as near as possible with the position of the risers, finishing tangential to the straight lengths at the top and bottom.

At the points where this curved line becomes tangential to the straight lengths fix the positions of the joints as at joint A and joint B, then project these points on to the plan, as shown.

The best oblique plane has now to be determined, so as to get the wreath out of as thin a plank as possible.

This is done by drawing lines from either joint tangential to the swell of the curve. Then taking the greatest departure of the curve from each straight line as radii, describe circles at either joint on plan, then draw a line from joint A parallel to a tangent, touching the tops of these circles, and you get the plan of an angle containing the true inclination of the best oblique trial plane. By drawing level projectors from the several points on the plan to intersect the line just obtained you have points, J', 1, 2', 3', 4', 11'; allow this line to revolve, using joint A, as a hinge, and the positions of these points on the x y line are obtained; project verticals to be intersected by horizontals from these same points in the developed falling line, and you thereby get points through which to draw a view of the falling line when seen in a position nearest approaching to a straight line. Now draw a right line cutting through the curved line in such a way as to leave the same amount of divergence on either side; produce this line until it intersects the joint lines viewed in this new position, thus you will obtain the vertical trace of an inclined plane that, on being resolved into the oblique plane of Fig. 2, will give the best plane of plank from which to procure the wreath.

The base line of Fig. 2 is projected from point 14 in Fig. 1. Reproduce the plan, marking off the tangent, A to 3, equal to the tangent, A to 6, in Fig. 1, the other tangent, 3 to B, will be a little less than that in Fig. 1, owing to the plane of plank intersecting the joint plane below the center of rail, the correct length being obtained by projecting the point of intersection first on to the x y line, then on to the line drawn from joint A and off again at right angles, to intersect the tangent 6 B, as shown. Transfer this reduced length of tangent to Fig.

2 and you get point B. Now draw a line through point B, parallel to the projectors, $3' 3$ or $2' 2$, in Fig. 1; produce the line until it meets the $x y$ line at point, 5; then, at point A, erect a vertical, to be intersected by a horizontal from point, 13 (Fig. 1). By this means you obtain point 6. Join point, 5, to point, 6, and you have the oblique plane in position, the vertical and horizontal traces being indicated by the lines, 6 5 and 5 B respectively.

At this stage the reader must, by studying the plan in conjunction with the oblique plan, strive to realize how the joint planes will interpenetrate the three planes now before us. It will be evident to him that the top joint plane will be vertical; that being so, the plan and elevation of A's two traces will be in one and the same straight line. For the sake of convenience we will use a parallel plane intersecting at point, 3. The twist bevel will be that portion of the joint plane cut off by the interpenetration of the vertical plane of which the $x y$ line forms the trace, the ground plane, and the oblique plane, so if we take point 3 as center, and stretch out to point 7, then with this as radius, swing down to cut the $x y$ line at point 8; on joining this point to point 10, we get the section of the joint plane we require, the angle at point 8 being the twist bevel. In this case we shall want an angle to apply over the joint, to be at right angles to the arris on either plane. This angle we may call the dihedral angle. It is got by stretching out from point 3 as center, so as just to touch the line, 8 10, and with this distance cut the line, 3 10, at 9, then 3 9 5 is the angle required. The reason for this will be evident if the reader realizes the relation the planes stand to each other when in their original position.

We now turn our attention to the bottom joint. The

joint plane in this case will be at right angles to the falling line of the straight rail; therefore when you have got the inclination of the lower tangent as indicated by line 13 7, draw from point 3 a line to meet it at point 14; this line being inclined at an angle equal to that of joint, B, in Fig. 1. Next introduce a vertical plane whose H T shall be at right angles to the plane of the lower tangent, this plane will cut the H T of the plane of plank at point 11. With point 3 as center, swing point 11 on to the xy line at point 12, and on joining point 12 to point 7 we have the line of intersection, this vertical plane makes with the plane of plank. In the following movements we must look upon the line, 10 7, as being the xy line. First get the twist bevel by taking point 3 as center, 3 14 as radius, and cut the xy line at point 16, join this point to point 12, and thus the twist bevel is obtained. For the dihedral angle drop a line from point 14 to cut at 15, join 15 to point 12, then from point 3 draw a line cutting through line 15 12, at right angles intersecting line, 7 12 at point 17; now take point 3 as center and stretch out so as just to touch the twist level line, 16 12. With this as radius cut the line 15 12 at point 18; then on joining the points 3 and 17 to point 18 you get the required angle. In order that the reader may clearly see the reason of the previous construction he must bear in mind that the lines, 18 7 and 18 3 are respectively contained in the plane of plank and plane of joint, whose vertical traces, by the way, in this case intersect at point 14 their horizontal traces intersecting at point 12.

The next process is to get the development of the plane of plank. Do this by making lines 5 19 and 7 19 equal to lines 5 B and 7 13 respectively, thus the horizontal

trace and the falling line of lower tangent are revolved out of their original position on the plane of plank and placed on the vertical plane, so that we may now view their true lengths and positions in relation to each other. By the aid of these two lines we are able to get other lines that may lie on the same plane as will be evidenced in the following construction.

To obtain the major and minor axis with which to draw the development of the center line of rail first project from the center of plan a line parallel to the H T, B 5; this meets the xy line at 24, erect a vertical to cut at point 20, then from point 20 draw a line parallel to line 5 19; on this line mark off a distance equal to 24 1, which will be the position through which to draw the major axis. By now using the trammel, you obtain the center line required, the points over the springings being got by erecting a vertical from point 2. We must now get the joint lines on the face mould; as these will be parallel to the intersections the joint planes make with the plane of plank, proceed to obtain them by revolving the point of intersection that these joint planes make with the lines 7 9 and 19 5 when in their original positions. Thus you get line 22 21 for that at the bottom joint, and line 7 23 for that at the top joint. Leave the completion of the face-mould until we have dealt with Fig. 3 as we have now to settle on the width of stuff required, which Fig. 3 will serve to indicate.

Fig. 3. First draw the line 1 2. At point 1 draw a line inclined equal to the dihedral angle for the top joint, and also draw a line at point 2 corresponding to the inclination of the dihedral angle for the bottom joint; then notice to what extent point 13 rises above the center of

joint at A (Fig. 1) ; mark this distance on the twist bevel line from point 8 in Fig. 2. The vertical distance of this point from the $x\ y$ line transfer to Fig. 3, measuring from point 1 downwards. By taking the radius of the circle that will contain the section of the rail and marking off at right angles to the line 9 1 you will obtain point 3. Through point 3 apply the twist bevel and reproduce the section of the rail as shown, enclosing same by lines drawn square and parallel to the line 9 1.

Of course there will be the same distance above line 1 4 as there is below. Thus you get the section of the plank at joint A. Transfer this to the face-mould by measuring from point 6 to the right equal to the distance 5 9 and to the left equal to the distance 5 11. Repeat the same process at the other end of the line 1 2 for the section of the plank at joint B. Take the greatest depth of section as the depth of plank and you thus are able to produce the rail from the least possible amount of stuff. It will be seen that as the rail leaves the joint at A, working up the twist bevel line the distance from 5 to 11 will increase until 5 11 will equal 5 9 and 5 9 will diminish accordingly, the greatest displacement occurring where the central falling line in Fig. 1 show the most departure from the line 13 14. In drawing the face mould this has been taken into consideration. At either joint allow for the application of the dihedral angles by adding and subtracting the distances got by using vertical projectors at each joint in Fig. 3.

We conclude with a few remarks on the practical part of the subject. Having got out your stuff with a thickness corresponding to that indicated in Fig. 3, sawn to the shape of the face mould, you will now proceed to make the joints, using the dihedral angles, and taking

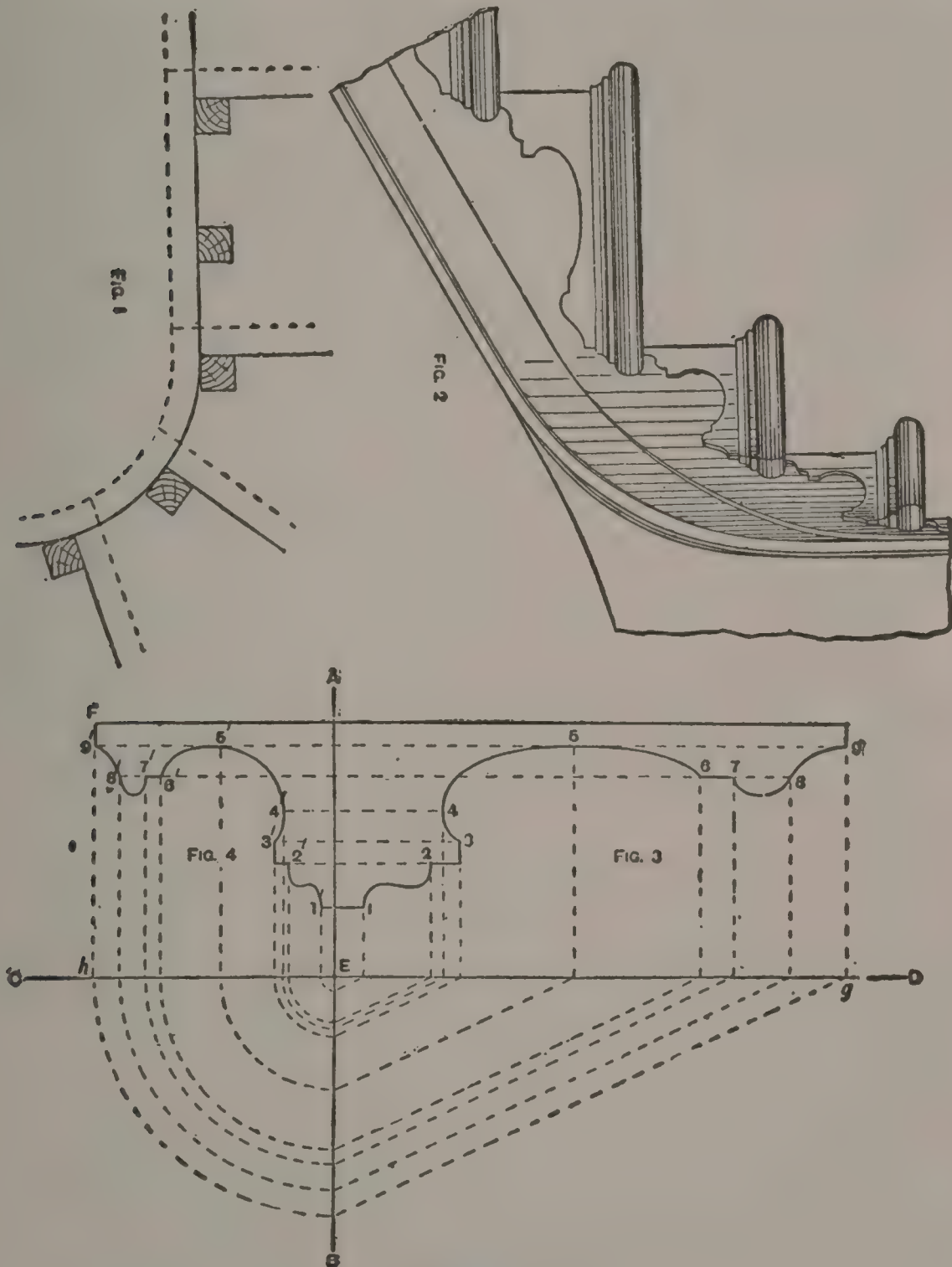
care that these are properly applied, by keeping in mind the relation existing between the inclination of the wreath piece and that of the straight length. Now apply the twist bevel on the face of the joint just obtained, allowing it to pass through the center of plank directly below point 6. Get the position of the center of rail in relation to the center of plank as is indicated in diagram No. 1. In getting out the square section of the rail, first saw off the top and bottom outside corners square with the face of joints, then work the inner and outer face of the square section from one joint to the other, exactly corresponding with the plan, being perfectly straight until the springings are reached, then following the radius of the circular portion. It will now be plain sailing to work the easings, which must conform to the developed falling line as seen in Fig. 1.

There are shorter methods than the one the purpose of this article has been to describe, but to thoroughly understand same the person must realize the fundamental principles which are included in the foregoing description. When he has gained a certain amount of facility he will be able to evolve quicker methods; but until he has become thoroughly grounded in the geometrical rudiments involved it will be suicidal for him to adopt any system whose sole aim is brevity.

LAYING OUT ORNAMENTAL BRACKETS FOR CIRCULAR STAIRS.

The accompanying illustrations (Example 13) show a method of setting out and arranging fancy brackets to the winders of a geometrical well hole stair. Fig. 1 shows a portion of the plan, and Fig. 2 represents a part

elevation, showing the bracket at the end of the ordinary treads, and also two in position at the end of the winders;



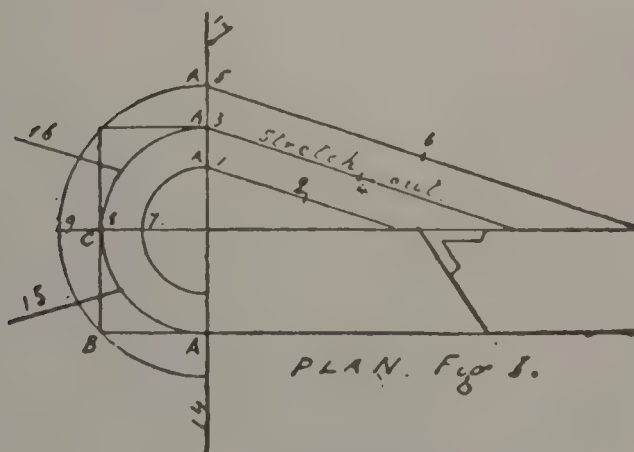
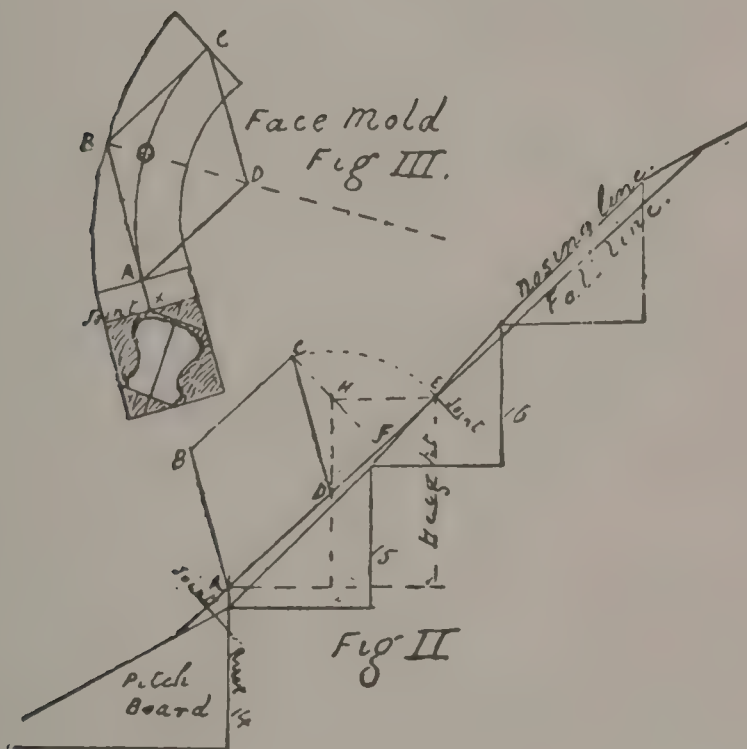
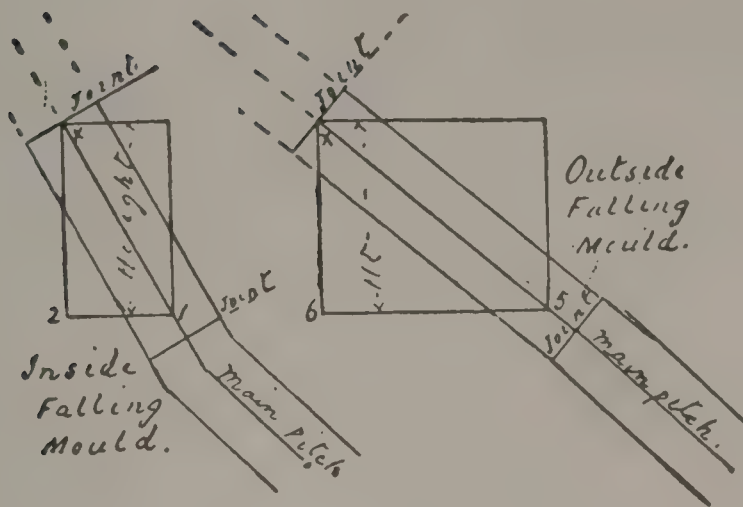
Example 13.

Fig. 3 showing the shape of the bracket at the end of the treads. Draw a line A B through the front edge of the

bracket as shown, and $C D$ at right angles to $A B$. Make $E B$ and $A F$ equal to the length of the brackets required. Fixing on points in the shaped edge of the bracket as shown by the figures, drop ordinates at right angles to the line $E D$, then join B to g ; then, with E as center and B as radius, describe the arc $B h$. Draw the ordinates $h F$, which give, of course, the length of the bracket; while, as will be seen, all the other construction lines are parallel to these just mentioned. Then, by projecting horizontally from the same points, the curves, etc., for the smaller brackets can be drawn, as will be understood from Fig. 4.

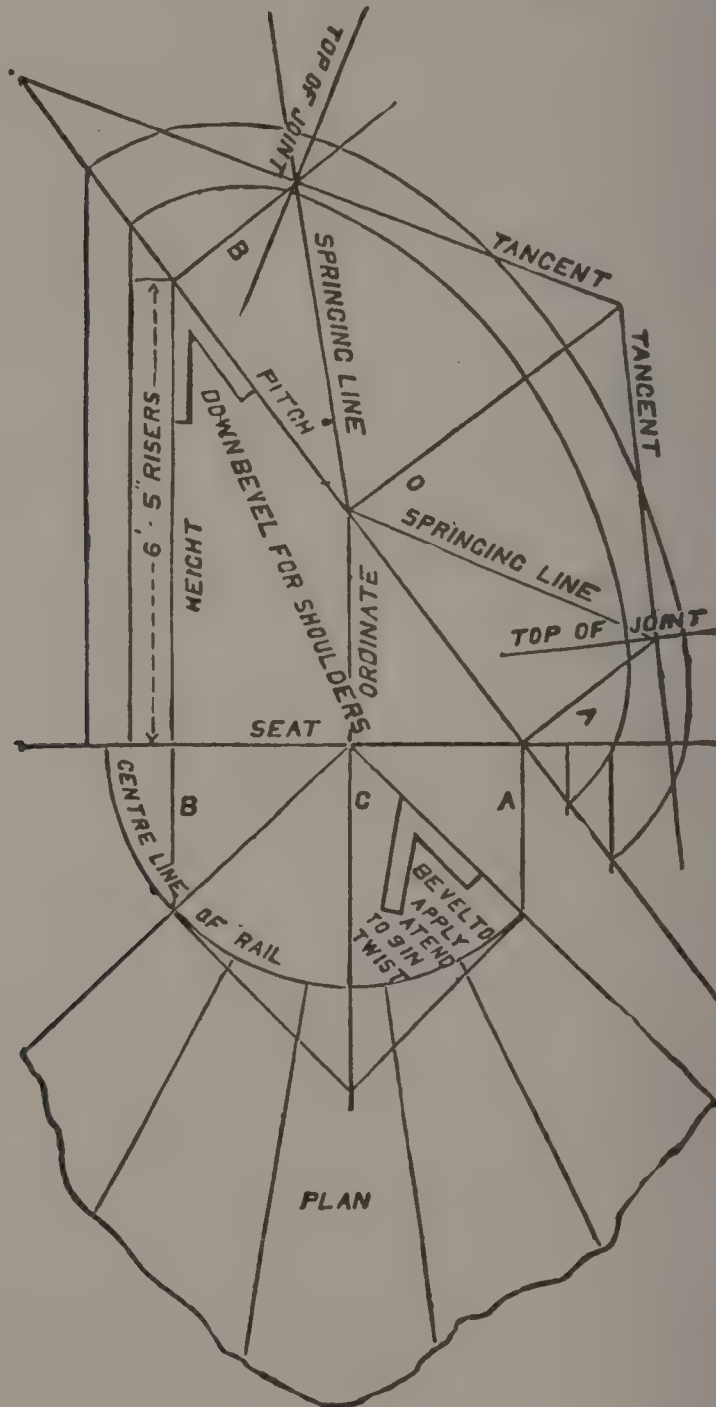
RAIL OVER CIRCLE AND TWO PITCHES.

See plan, Fig. 1, Example 14, showing inner and outer circle stretched out. Transfer half of the inner 1, 2 to 1, 2 above for base of falling mould, set up the height and form square as shown; draw the center line from 1 to x , continued to meet main pitch line; set off half thickness of rail each way, and form an easing at the angle, mark the joints from falling line, and you have pattern for inside falling mould. Get the outer one same way, and notice the falling mould being near straight with main rail. There will be an easing on lower straight rail, and a ramp on the upper one. Fig. 2 is development round square, well on center line. The rail is lifted at lower end, and lowered at top end of wreath. Notice the arc struck with radius $D E$ and cutting straight line $F C$, which is square from falling line passing through angle at H . Join $D C$, and $A D$ and $D C$ are tangents, turn them over work way and they become $A B$ and $B C$. Transfer them to Fig. 3, draw line $B D$, extended. Make



Example 14.

D O same as A B on plan, and you have three points through which to pass the center line of face-mould. Find



Example 15.

centers on line B D, extended to strike the curves for face-mould. Set off half of rail on each side of center line from the bevel at each end, and its width in the

middle. Notice short shank at lower end. The bevel is got from parallelogram, and applies to all wreath joints. The application is shown at Fig. 3.

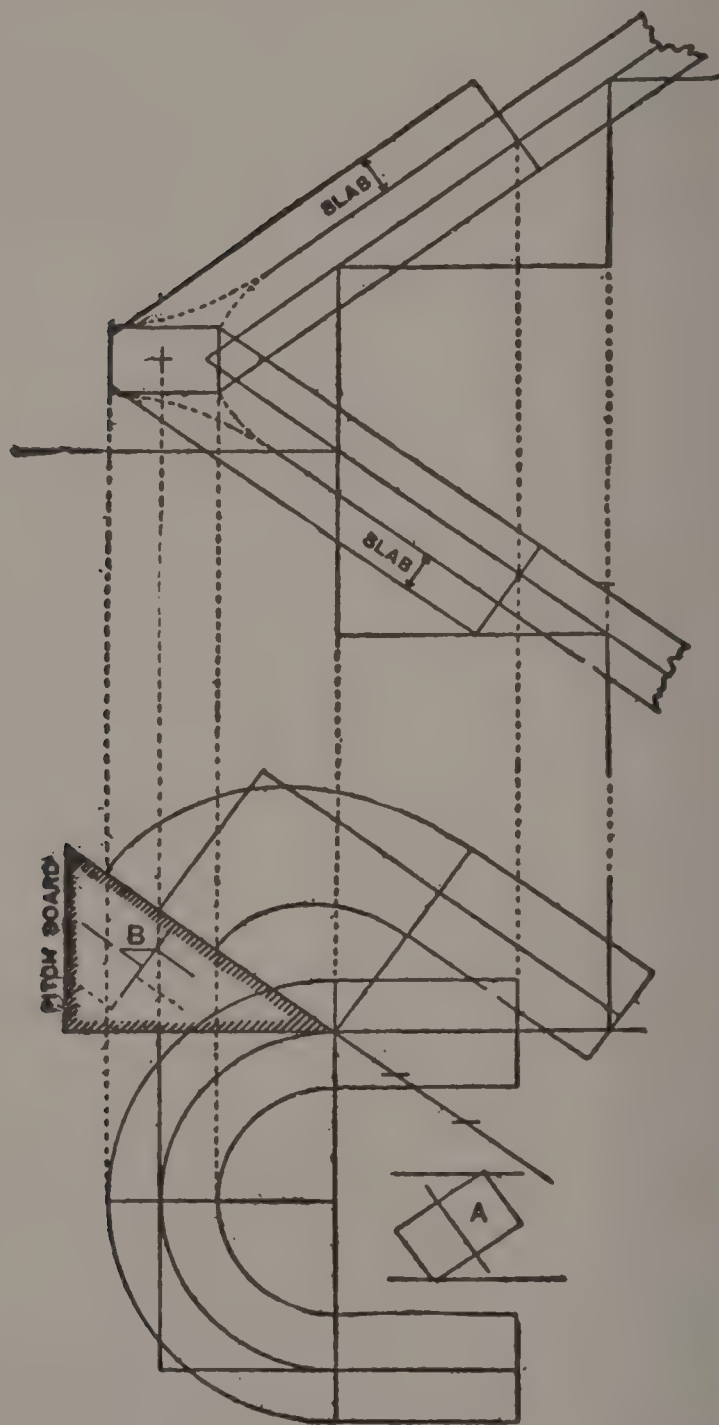
AN EASY WAY TO LAY OUT A WREATH.

Make a square as shown on plan, each side to equal radius of center line of rail; from corner to corner of this square draw a line extended and marked ordinate from this square over a line marked seat through top corner of square. Now bring up the lines marked A B, Example 15, from the other corners of square, extend one of these and on it put height of six risers from seat line upwards, and from this point through where line A meets seat this line is called the pitch or major axis of the ellipse; from points on this line at height, ordinate, and corner of square, square over these lines as shown, and make them equal to those marked the same below. I have shown bevels; now trace elliptic curves with a string.

POINTS IN PRACTICAL HANDRAILING.

It seems to be the custom, and is given as a rule, by most authors of handrailing, to locate the risers, landing and starting, on platform stairs, just half a step from the crown tangent on the plan. When this is done the wreath must be taken from the center of the plank, which is unnecessary when the risers are placed in the right position; and, besides, by working from the side of the plank, a more graceful rail is the result. When this rule is departed from, and the wreath is taken from the side of the plank, it is deemed necessary to draw an elevation, and

to develop the tangents, in order to find the position of the risers, landing and starting, so as to bring the rail



Example 16.

to the proper height on the return flight. We propose to show how, by the use of the pitchboard, to locate the

risers, landing, and starting, and also how to produce the face-mould, without drawing an elevation or developing the tangents; and the plan will apply both to half-space and to quarter-space landings, often saving both time and material. There is no springing of the plank, the crown tangent remains level, and the pitchboard gives the level for the center joint. In very small wells, however, it is better to locate the risers at the springing of the well; the crown tangent will then be on the rake, and the rail much easier to work. Therefore very small wells require different treatment. The example given is for a rail for a properly constructed stair arranged for the risers, landing, and starting, to fall on the springing line. Having got the rise and run of the stairs, make the pitchboard, Example 16. We have assumed a 10-in. tread and a 7-in. riser, and a handrail 4 in. by $2\frac{1}{2}$ in. The first step is to draw the bevel (which is given by the top and riser edges of the pitchboard), and on it draw the square section of the rail, as shown at A, to get the thickness of plank required, which is 4 in. Next gauge off half this thickness (namely, 2 in.) from the top edge of the pitchboard, likewise half the thickness of the rail, then draw the line from one to the other (marked B), parallel with the bottom edge of the pitchboard. The length of this line added to half a step gives the distance the risers, landing and starting, must be located on the plan from the crown tangent and is likewise the radius for the center line of rail—that is, if the risers are required to be on the springing line. The plan of the rail is given, showing clearly how it is drawn from the pitchboard. An elevation is also given, to show how the wreath is taken from the plank. The face mould is drawn in the usual manner, with string and pins.

CONTINUED RAIL WITH WREATH.

In Example 17 is a continued rail for large wells, and it also applies to, from rake to level, when only one wreath piece will be required, the mould for the other half, being level, is the same as shown on ground plan of rail. A side elevation is made, showing the piece of plank dropped to a flatter pitch to save material, a 4-in. plank is enough. Where the pitch of straight rail carries the rail too high at the center at the back of well, it is not only better, but easier, to ramp the rail as shown, than to cant the plank down at the center joint. The mould is drawn from pitch of wreath piece, and is figured, and curves drawn with the aid of flexible strip.

In Example 17 is a rail for stair with one step in the well. The mould is got out exactly the same as No. 3, the only difference being in setting up the height. The block gives the bevels.

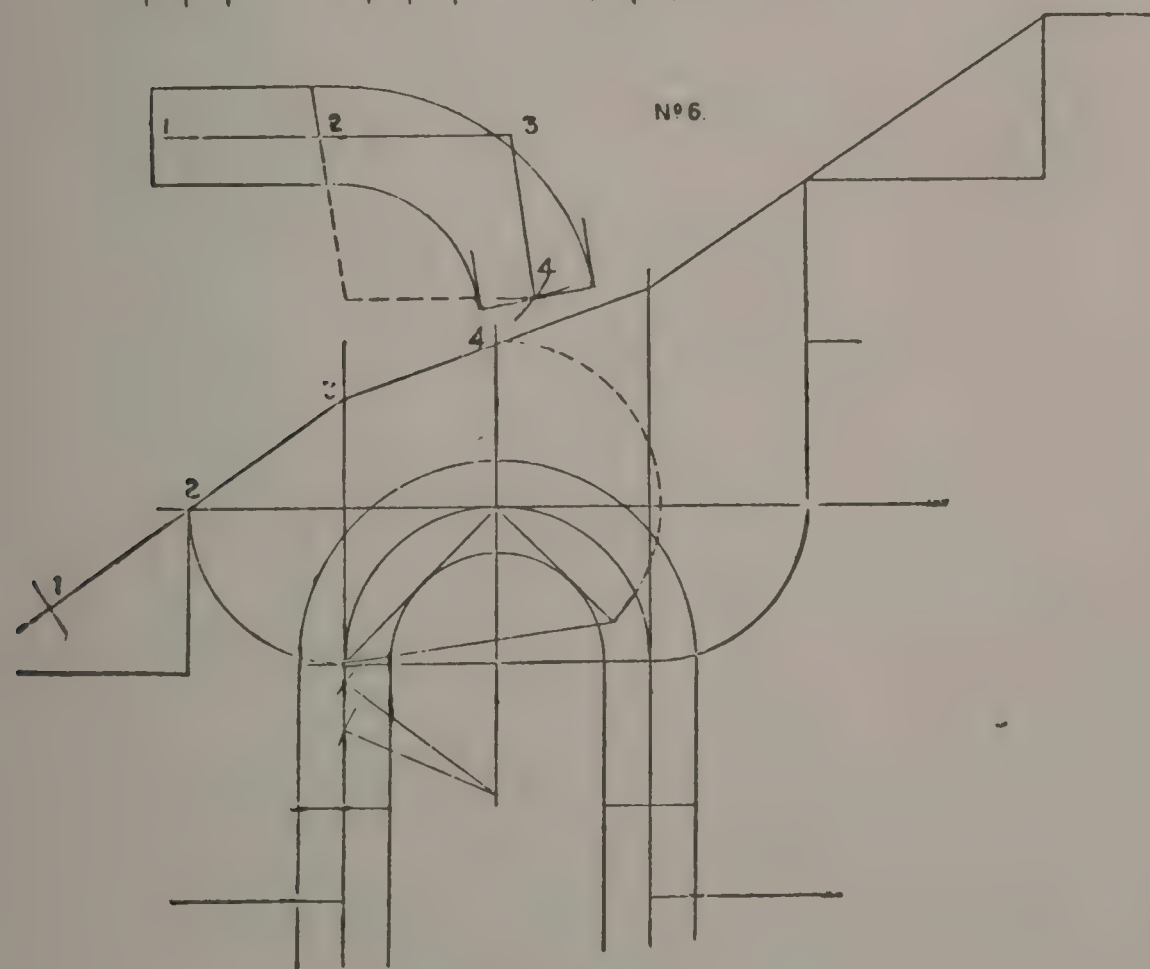
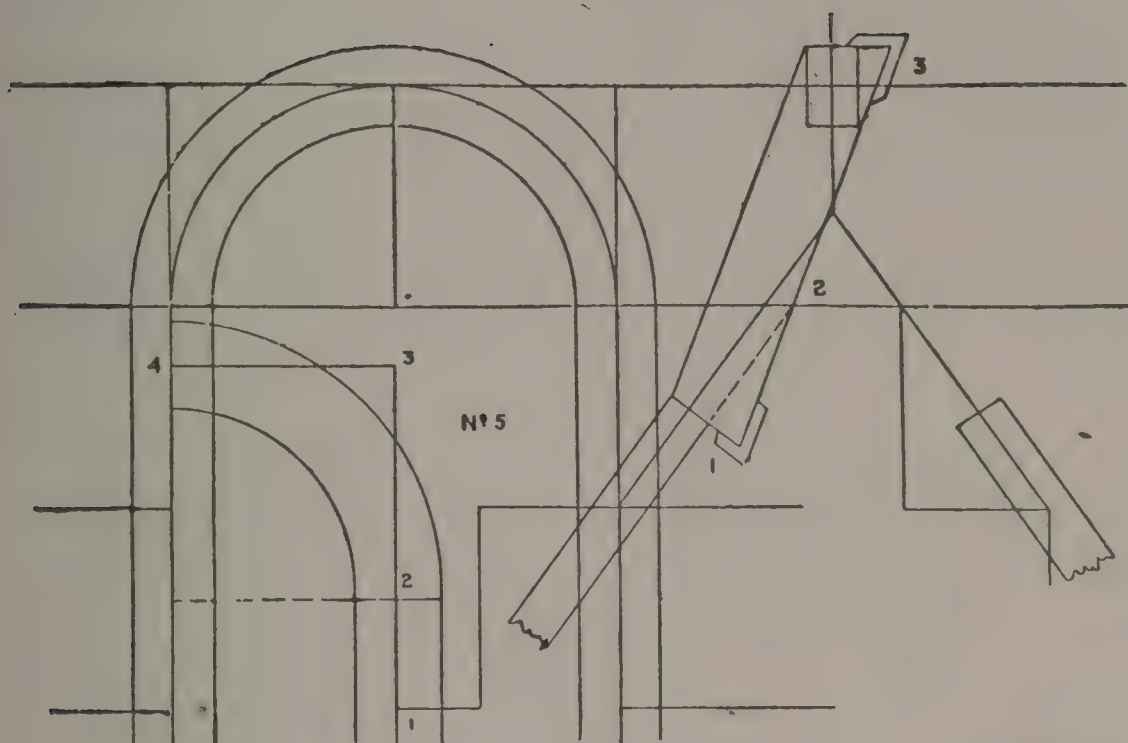
A QUARTER LANDING WITH WREATH.

Example 18.

Fig. 1 shows the plan of center line of rail (the radius is equal to half a step) and the position of risers, landing and starting. Enclose the center line with tangents, as shown, and draw the half width of rail on each side of center line as shown by the dotted lines.

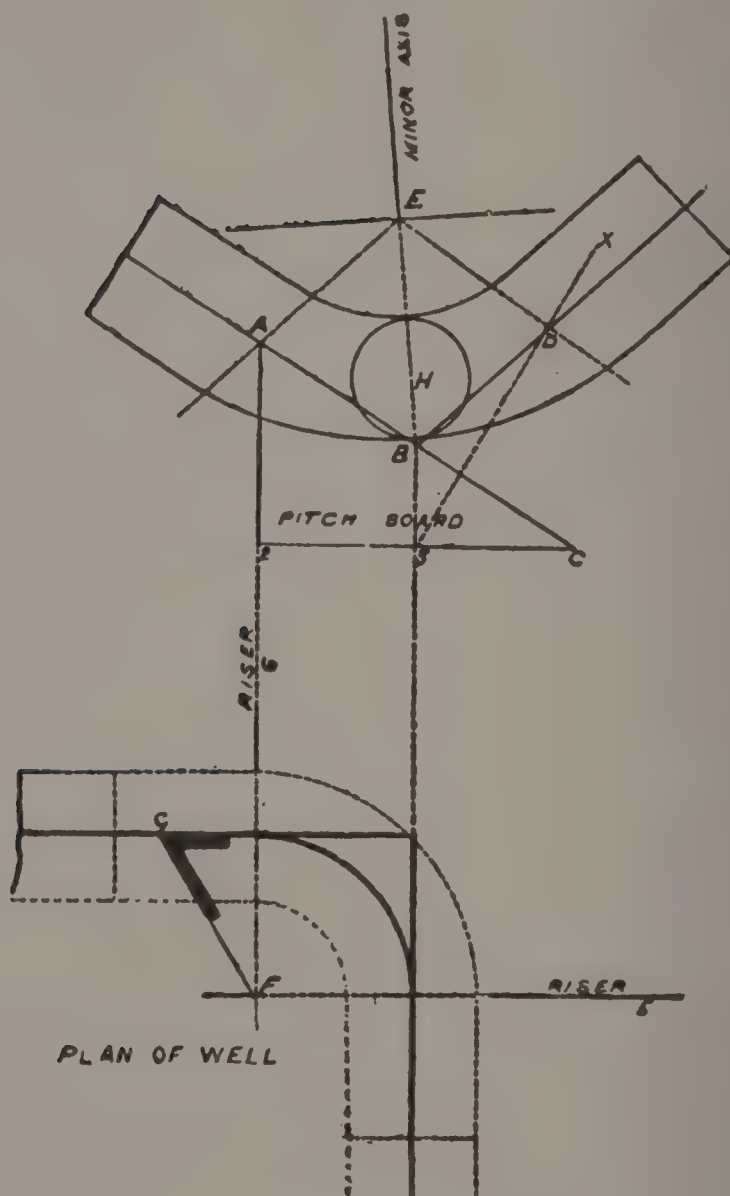
Fig. 2 is the development of tangents.

Square up the center line of rail and springing line at 2, 3, apply the pitch-board to the line 2, as shown, and mark the pitch of rail A C; continue up the lines 2, 3. To cut the pitch-line at A B, draw a line indefinitely at



Example 17.

right angles to A B, from point 3 place the compasses at B; and for radius the point of pitch-board, C, cut the line 3X at D, draw a line from B through D; then the



Example 18.

lines A B and B D are the tangent lines. Place compasses at A, and radius A B, draw an arc at E, and from D, with same radius, cut the arc at E, and lines drawn from the intersection at E, through A and D, give spring-

ing line of wreath; and a line from B, through E, is the minor axis, and a line at right angles to the minor axis, through E, is the major axis.

TO GET BEVEL AND SET OUT FACE MOULD.

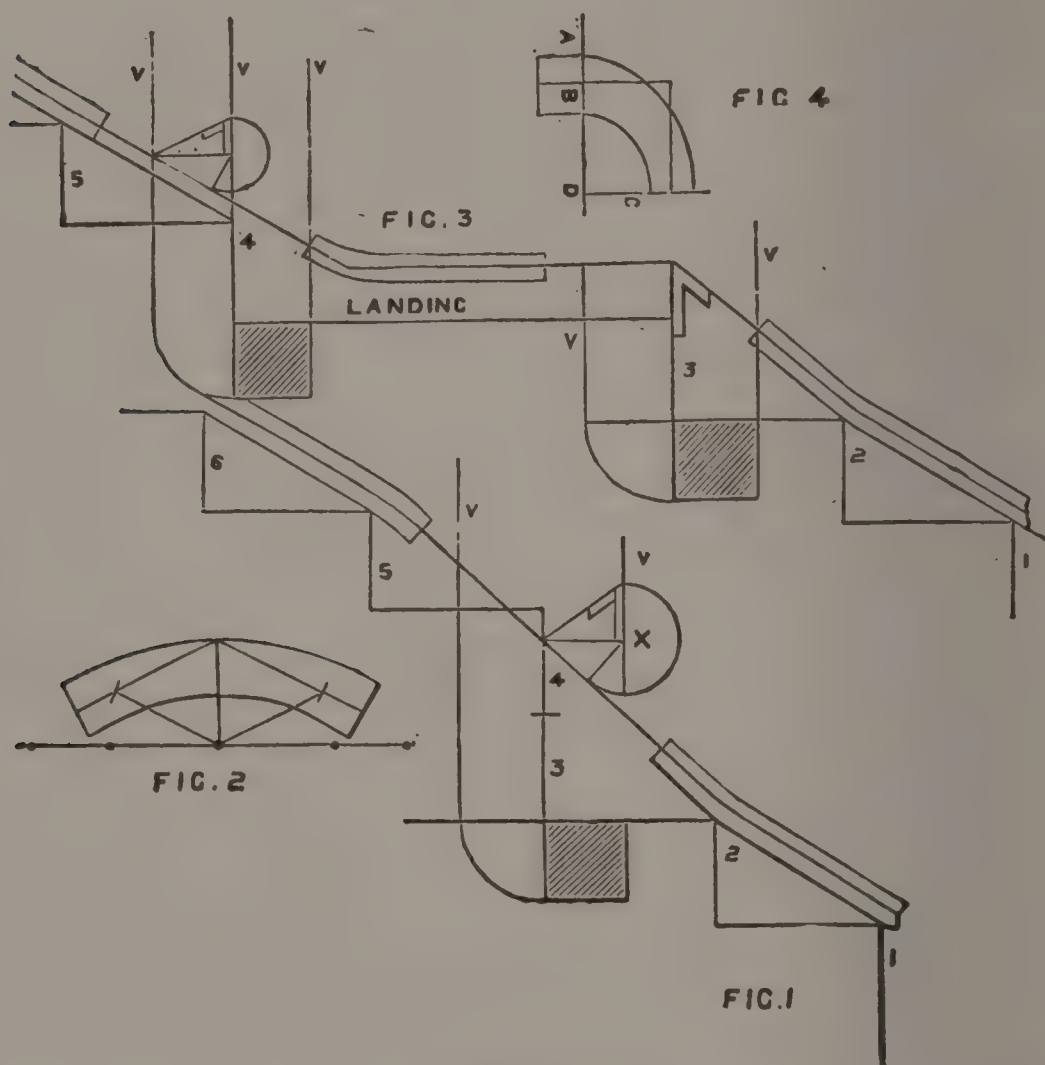
Place compasses at E, and for radius, an arc touching the line A B; place compasses at F, Fig. 1, and cut the center line of rail at G; draw a line from G to F, which gives the bevel for both ends of wreath. Place your compasses at G, and for radius half width of rail on bevel line, apply the distance on each side of center line at the shank ends of the face mould, and continue up to the springing line; place compasses at E, and for radius, the radius of center line of rail on plan, cut the minor axis at H; place compasses at H and for radius the half width of rail on plan describe circle as shown, and set trammel, or use straight edge, and mark the elliptic curves through the three points, all joints to be made square to tangents and to face of plank.

ANOTHER METHOD OF QUARTER SPACING.

Example 19.

For quarter spacing, 1, take for well, say, half a step landing and starting, lay down quarter, set up the risers, 3 and 4, in angle of well, on each side of which square out two steps; draw the verticals, V, which represent the springings; draw half thickness of rail from corners of risers, 2 and 5, for center line, and connect the pitches; keep joints at easings clear of springings; draw bevel line at +; with + for center, and line touching pitch for

radius, turn the arc cutting at V, and draw the inclined line. In the angle is seen the bevel for both ends of wreath, as pitch of tangents over quarter are equal. For F mould, Fig. 2, draw A B, the major axis; square out



Example 19.

the minor length of diagonal at quarter, Fig. 1, take length of pitch over quarter from 4 to vertical for radius, and each end of minor for centers, and make intersections right and left, and connect the springing and tangent lines. Extend the latter, to allow for the bit of straight to the joints at easings, mark radius of quarter for center of mould on minor; set off on each side half

width of rail, and from these points draw lines parallel with tangents, cutting the major right and left. These are the points to fix pins for striking the curves. Make the joints square to tangents. Fig. 3 is for the half space. Lay down landing line, square out the steps on each side, draw center line of rail half a step above landing; from corners of steps draw the center lines, to join it. The F mould and bevel for left side are got exactly as Figs. 1 and 2. For F mould, Fig. 4, draw line, A B D, square out, B, radius of quarter, take length of pitch from level to vertical and square it out to C; set half width of rail on each side; set half width of shank on each side of B, which is seen marked on top of bevel at pitch. Take for radius from D to outside of shank at A, and with outside at C, for center, cut line A D on both sides of D. These are points for pins, to sweep the outside curve. Repeat this from the inside for the inner curve. These directions will do whether moulds are curved between the springings or straight, so as to stand over plan, and merely easing the angles round, to suit the hand.

LAYING OUT A WREATH FOR QUARTER SPACE.

Fig. 1, Plate 3, shows the ground plan. Two sides of the square are tangents to a quarter circle, which is the line center of rail. Let us now place the risers on the plan, in such a position as will throw straight wood of wreath on the same pitch as the stairs. To do this, set off from A, half a step on each side of the square; now draw riser landing, and riser starting; set off from these the square steps, as shown. Any alteration of risers from the posi-

tion given, would cause the wreath to be in two pieces, which in some cases is not objectionable; but here we have fixed the risers for a plain and simple wreath to be in one piece. In view of this, we will now make all clear and distinct in the following manner: At Fig. 2 (which is a square just equal to Fig. 1), extend the side from D; now place the pitch board on upper side of square, and draw from C through A; make A F equal A D; square over from F, cutting the pitch at E; draw through F; square with A E; take A as center and E radius; draw the circle, cutting through F at B; join it and A. This gives B A C an angle of tangents for the mould. Set a bevel or rule to it; this being done, lift the rule and lay it on a piece of board, shown at Fig. 3; now mark B A C; extend the lines to right and left; draw through B parallel with A C; make B N equal A C; draw from A through N—this line is the short diameter of a semi-ellipse, and to be correct, A N must equal O D, shown on square above; draw through N, square with N A, and we have long diameter; make N O equal O C on square above; set off on each side of O half width of rail.

The width of mould on straight parts is obtained by having a bevel for joints. To find this bevel, also find the long diameter of a semi-ellipse. Take any point, below N, say V; draw from it to the right; square with V N; come to Fig. 2; here divide O D in J; make D R equal D J; draw from A through R, cutting at P—this gives A P as half the semi-ellipse on long diameter (this line is also pitch of plank); take A as center, and with any radius draw the arc L D; return with it to Fig. 3; here take V as center, and draw arc L D; make both arcs measure equal; draw through V and L, cutting at J;

draw J K parallel with C A on mold; take N as center, and for radius a circle touching, J K cutting at T; draw from it through V—this gives bevel W to apply on both joints; make N P equal A P, Fig. 2; set off half width of rail below V, and draw it parallel with V D—this gives 2 V, as half width of mould on each side of S S at the joints; then 3 V being set off on each side of P, gives width of curves. The width of curves being thus given on long diameter, and width of rail on short diameter, directs the way by which we find points for pins, in order to strike the mould with a string, as shown. Make the joints square with S B and S C.

[Here it may be mentioned that plank for wreaths is required to be as thick as the rail is wide]; in other words, if a rail is four inches wide have plank for wreaths four inches thick. Now let us cut the stuff square through; then face one surface of the piece out of wind; this being done, lay the mould on; mark the joints by it, and at the same time mark on surface of plank, the direction of tangents, which are on the surface of mould; by means of this, joints may be proved as to their being correct or otherwise; have a nine or twelve inch square, which is perfectly true, and apply it, by bringing the stock against the joint; see that edge of blade, and surface of plank agree; and for the other application keep the stock against the joint; see that blade of square, and line on the surface of plank agree. Here remember that joints are the most important matter in hand-railing, for if they are not correct, it will be impossible to make the rail stand over its plan; no attempt at forcing the rail to its position will answer, because there is a liability of breaking the joints, and rendering the work useless. [Keep these facts in mind.]

Now proceed, and give the wreath piece its cylinder form, by drawing the tangents across the joints, and square with surface of plank; also square over both edges opposite line through O; this done, mark half thickness of stuff on each joint, and on edges opposite O. Now take bevel W, and apply it to the joints; mark square sections of rail as shown; then cut off slab X on the left from top side, and slab X on the right from under side; work by the bevel, and at the same time have the edges square with joints; this being done, square over half thickness of rail, continue it along beveled edges, and square with joints; set off on this line the distance S B, and through the extreme point draw the spring line by the pitch board; the line made by bevel W on square section being continued on surface of plank, and the mould having tangents, as S B and S C on both sides, lay it on the piece; keep its outer edge flush with beveled edge and inner edge fair with dotted line on the right. Now tangents on the mould are directly opposite lines on surface of plank—one end of mould projects past the joint, as is always the case in every application. Mark along the edges; this done, apply the mould in like manner to the other side. Now take off the slabs, and in doing so, hold the plane in the same direction as spring lines on beveled edges; this being done, we are ready to bring the piece to a thickness, which is quite simple, because the square section of rail is marked on each joint, and the thickness on both edges opposite short diameter through O; here the slabs are equal, and when taken off, the wreath piece is found to be of a parallel width throughout. This could not be the case had the mould been prepared in a careless and slovenly manner, as is too often done, followed by cutting, filling, and tinkering

to get the thing look like a wreath. Avoid this by starting aright, and working true to every line. Remember that "Jack of all trades and master of none" is a homely maxim, but true. Learn to do one thing well, it matters little what it is, only do it well, and you need never have fears as to success.

In regard to the application of moulds for giving wreath pieces their cylinder form, there is only one correct way, and that is, keep tangents on the surface of mould opposite tangents on the surface of plank. This is the whole secret in a few words. Here understand that it is the bevels for joints which direct the tangents on surface of plank.

TO OBTAIN LINES FOR SIDE-WREATH.

Fig. 1, Plate 4, shows the ground plan for a side wreath, starting from a newel; the wreath to form its own easing from the miter-cap; its straight wood thrown on the same pitch as that made by a square step and riser; the newel to project from straight string any distance desired; two or more ends of steps at the starting are curved. To do this proceed as follows:

Fig. 2 is the elevation of a square step and riser; the center of short balusters indicated by 2 E, on which rests the under side of rail. Here the height of newel is determined as being equal to the length of a short baluster and one riser added; this means from top of first step to underside of miter-cap. Now assume 2.3 as length of tangents for ground plan. Make B 3 on the left equal 2.3 (here observe that B is the center of a baluster standing in the same position as that of 2 on the right); draw from

B any angle to suit projection of newel, say B N; make B N equal B 3; draw from N square with N B; now draw from 3 square with 3 B, cutting line from N at P, thus making P a center, from which is drawn the curve on ground plan. Set off from N sufficient wood for miter; this done, lay the pitch-board on B 3, and draw pitch B C.

To find angle of tangents for the mould, draw from N square with B 3, cutting at T; draw from it square with B C; take B as center and N radius; draw the circle cutting line from T at A, join it and B; this gives A B C as the angle. Before leaving here, find half the long diameter of the semi-ellipse, in order that curves on mould may be drawn by means of a string. To do this, draw from B square with B N; draw from 3 parallel with B N, cutting at J; make 3 K equal B J; draw from C through K; make 3 H equal 3 P radius; square down from H, cutting at V. This gives V C as half the long diameter; the same line is also pitch of plank on its surface along the square edge. Now set a rule to angle A B C; this done, lift the rule and lay it on a piece of board, shown at Fig. 3; mark A B C; extend B C, say to J; draw through it square with J C; set off from A sufficient wood for miter, or to equal that shown on ground plan; work the joint square with A B; this being done lay the piece down, bring a straight edge against the joint, fasten both, lay down a strip of same thickness, and draw on it the line through A square with A B; this done, make A V equal V C, Fig. 1; square up from V; make V 3 equal radius P 3; set off half width of rail on each side of 3. The width of mould is obtained by having the bevels for joints. To find these bevels, draw a line any distance below the long diameter, but parallel with it; say the line is that of S L on the right, take any point on

this as L; square up from it, cutting at N; now come to upper part of plate at C; take it as a center, and with any radius draw arc D S; return with same radius to L as a center; draw the arc D S; make both arcs measure equal; draw through L D, cutting at E; draw E F parallel with B C on mould; take N as center and for radius a circle touching E F, cutting at H; draw from it through L. This gives bevel Y for joint on straight part of wreath; its application is shown on square section above. The line L E having already given bevel W, its application is shown on square section to the left.

To find width of mould at both joints, set off below L half width of rail, which draw parallel with S L; this gives K L to set off on each side of J, at joint on mould, and F L to set off on each side of A to the left. Now find points for pins, and sweep the curves with a string which completes the mould.

The plank having been cut square through, and joints made, apply bevels W and Y; mark square sections of rail, as shown; this done, take off the slab on outer edge of straight part, and from top surface, work it by bevel Y, and at the same time have beveled edge square with joint; this done, apply a square, and mark half thickness of rail; continue this along beveled edge and square with joint; then set off on line just made the distance C J, and at its extreme end mark the plumb-line by the pitch board. Now lay the mould on, keep its outer edge flush with beveled edge of stuff, and its joint at wide end even with joint of stuff, making line A B on mould stand opposite line on joint made by bevel W; mark surface of plank as edges of mould direct; apply the mould in like manner to the under side. Now take off the slabs, and in doing this, hold the plane in the same direction as

plumb line on beveled edge. The wreath piece having its cylinder form, cut off under slab of straight part and under slab at joint A; here mark the miter, and cut it, but not entirely through until the moulding is done. Now work off the remainder of slab as concave corner directs, forming the best possible easing; gauge to a thickness and we have a perfect side wreath.

PLATE 5.

GETTING MOULDS FOR A WREATHED HANDRAIL.

The plan (Fig. 1) shows a portion of geometrical stairs with winders at the commencement and in the half space; the lower winders cutting into a newel post and the upper winders radiating from the center of the well; the last riser in each flight finishing in the springing. A portion only of the handrail is shown, the dotted lines indicating the wreathed part.

The preliminary construction, to obtain the face moulds, is to enclose the center line of the rail in plan within tangents as A B, B C, C D, D E (Fig. 1). Draw also the diagonals A C and C E. Next make a stretch-out in elevation of the center line of rail as in Fig. 2. To do this, measure along the curved line A C E (Fig. 1) with a series of short steps in the compasses, and mark a like number upon any straight line, as A E (Fig. 2). Transfer the points 1 2 3 4 5, where the risers cut the center line, in a similar manner, and the line A 1 2 3 4 5 E will be a stretch-out of the center line in plan. Next from E on the top springing line set off the seven risers, also two below A. Draw horizontal lines from these points to intersect perpendiculars raised from the points in the line E A, and the outline of the steps in the well

will be shown. Draw a line touching the salient angles of the steps; this is the nosing line. The nosing line over the two fliers will give the common pitch, which may be transferred to the upper steps, above the springing E. On the nosing line draw the rail to the required thickness.

It is usual and necessary to raise the rail over the winders more or less, according to their steepness, and in the present instance the rail has been raised 2 in. perpendicularly. Set this amount up above the nosing line, and draw the rail parallel with the nosing line as shown. Ease off the rail into the straight parts with a gentle curve, and draw the center line shown dotted in the example. Produce the center line to cut the springing in *e*. This point, with the points *f* and *g*, where the center line cuts the springing line A and the center of the well *c*, locates the heights of the tangents upon the tangent development now to be made. Draw the perpendiculars A B C D E (Fig. 3) at a distance apart equal to the distance apart of the same points in the plan (Fig. 1), and draw the steps as they occur on the tangents in plan, projecting the heights or rise from those previously drawn in Fig. 2. Draw also two steps above the springing to obtain the common pitch, and draw the center line of the rail, producing it until it cuts the second line D. Next project the points *e f g* (Fig. 2) to the corresponding lines on the development (Fig. 3), thus obtaining the points *e' f' g'*; through these points draw a straight line, which, with the line *h i*, forms the elevation of the tangents E D C B A (Fig. 1). This wreath forming a semi-circle in plan, should be made in two pieces, with a joint, at *c*; and a face mould will be required for each half, as the pitches are different as shown in Fig. 3.

To obtain the true shape of the section of the imaginary prism whose base is represented by the lines $A B$, $B C$, $C A$, and two of whose edges are shown developed in the line $f g'$ (Fig. 3) the length of the third side $A C$ is required. Therefore upon the horizontal line $g g'$ set off from j perpendicularly under point f' the length of the diagonal in plan $A C$, Fig. 1, which is point k in Fig. 3. Join this point to f' and the line $F K$ is the true length of the diagonal forming the third side of the section containing the face mould.

To draw the face mould (Fig. 4), at any convenient place draw a straight line $a c$ equal in length to $f' k$ (Fig. 3). Take the length of the line $f' o$ in the compasses, and from a (Fig. 4) as center describe an arc and with $o g'$ as radius and c (Fig. 4) as center, describe another arc intersecting the former at b . Join points $a b b c$ producing the tangents of the face mould. Next draw lines through a and c parallel with the tangents and intersecting at X , which represents the axis of the cylinder or center of well; the lines $x a$ and $x c$ being the springings. The inclination of these tangents being alike, the minor axis of the elliptic section lies at right angles to the diagonal of the prism, and the major axis at right angles to the minor or parallel with the diagonal as shown.

To obtain the width of the mould at each end, take the perpendicular distance between the tangent $b c$ produced and the springing point a in the compasses (Fig. 4) and lay it off anywhere in the elevation of that side as $l m$ (Fig. 3). On this line describe a circle equal in diameter to the width of the rail in plan, and tangent to this circle draw lines parallel to $l m$, cutting the perpendicular A . A semicircle described on m from these points gives the required width of the mould, and circles

of like diameter should be described on the tangent lines produced, of the face mould (Fig. 4); then parallel lines to the tangents and touching the circles should be drawn to intersect the springing lines, which will give points in each of the elliptic curves to be drawn. To obtain the length of the elliptic axis with which to trammel the curves, lay the trammel rod on the springing line in Fig. 1 with its end at x , and mark the inside of the rail p . Next lay the trammel rod on Fig. 4 with its end at x' and the point p' lying on the major axis and mark the point q' where the rod crosses the minor axis; with these two points on the rod kept upon the major and minor axis respectively, the end of the rod x' will move around the required elliptic curve, which may be dotted in and the line filled in freehand. The bevel shown in the acute angle at m (Fig. 3) is the bevel to use at each end of the wreath piece for the purpose of sliding the mould to mark the curves on it for cutting the sides of the wreath. To obtain the face mould for the upper wreath proceed in a similar manner up to the point where the direction of the elliptic axis has to be determined. In this case the tangents hi and if not being inclined alike, the minor axis of the ellipse will not lie at right angles to the diagonal of the face mould (Fig. 5). To obtain its direction produce the line hi to s , where it intersects the level line draw from the lowest point of the lower tangent. Produce the tangent $h'i'$ (Fig. 5) making $i's'$ equal in length to is (Fig. 3); from s' draw a line to the end of the diagonal f'' , which line will be parallel to the minor axis of the elliptic curves; and the major axis should be drawn at right angles to this through the center x . This wreath being inclined at different pitches in the two directions, will require two bevels, and the mould will be of differ-

ent width at each end. To obtain the bevel and width for the top end, draw a line perpendicular to $i' s'$ from the springing f'' and set this off in the elevation of that side from t to u (Fig. 3); the acute angle giving the bevel and parallels on the width of the rail in plan giving the width of the mould on the line D . Draw a circle of this diameter on the upper tangent (Fig. 5) and draw lines to the springing parallel to the tangent and touching its sides. This will be the starting point of the curves. Measure the length of the shanks as shown in Fig. 3 along the center line, and from the springing lines to the joints, and set these off from the springings on the moulds. Draw the joints at right angles to the tangents.

PLATE 6.

THE WREATH LANDING ON A LEVEL FLOOR.

Figure 1 shows the ground-plan of stairs landing on a level floor. The risers are placed in a position that will give to the wreath the best possible effect. Here the face of riser landing is made to stand on a line with center of rail at L . Its face at the cylinder should be curved as shown; which may be done by making a slit on the end so as to form a veneer; then work a block hollow; then glue and slip it into the cut on riser, thus forming the required curve.

The whole arrangement of plan is simple and will give the wreath a more finished appearance than any other. But if there is no regard paid to this, then the result, without doubt, will be a deformed and crippled wreath, and the effect of everything destroyed. Always commence by laying down a correct plan, for this or anything else; and work exactly to it.

Here observe that the height from riser B to that landing is just two risers. Now we want the under side of level part of wreath to stand half a riser above the floor, in order that long balusters on square steps may answer for the landing. This understood make an elevation for pitches of wreath, by squaring up riser line B and radius N L as shown, the radius indicated by dotted lines through L and N (shown above); let the space between dotted perpendiculars through N and S equal N L. Now take any point on riser line from B, say O; here form a square step, above which set off two risers, draw floor line, and about it set off half a riser; mark under side of rail, and from it set off half thickness of rail, cutting at S, which is a fixed point. Now come to square step; here let under side of rail rest on center of short balusters; set off half its thickness, and draw pitch of stairs cutting through E T, which are fixed points; draw from S through T. This gives E T and T N as the pitches for lower part of wreath; draw a line through point E square with E N. Form a square below E J; this done, draw from L, parallel with T E, cutting at 4; draw from 4 through 5; and in like manner draw from E J R parallel with 5, 4; this done draw through R square with 5, 4. Now make K A equal the height E N; draw from D through A. This line is the pitch of plank and long diameter of semi-ellipse.

To find bevels for points on lower part of wreath, take J as center; and for radius, a circle touching line T N, cutting at H; join H R; this gives bevel W for center joint. Now take E as center, and for radius, a circle touching line 4 L cutting at P; draw from 5 through P; this gives bevel Y for joint on straight part of wreath. To find half width of mould at each point, set off below E J

half width of rail cutting the bevel lines. Then the distance from H to the point where half width of rail cuts bevel W, is half width of mould at center joint; and in like manner, the distance from P to point on bevel line Y gives half width of mould on straight part.

We are now ready to draw the mould. To do this, have a board with jointed edge, run a gauge line on the face, lay edge of board on the pitch A D, and mark on its face the points A B C D, these square over, as shown at Fig. 3; here make D E, B T, A N equal D J, F E, K 5 at Fig. 2; draw from T through E; again draw from T through N. These lines are tangents on the mould, and to be correct they must equal the pitches E T and T N, as shown on elevation above. Now make C O equal radius L N on plan; set off on each side of O half width of rail, to find half long diameter of elliptic curves. To do this, come to Fig. 2; here make R K equal R 5; set off on each side of K half width of rail, and draw dotted lines parallel with K A, cutting the pitch at 2 and 3; this gives C 2 for inside and C 3 for outside curves on the mould, as shown at Fig. 3.

Now find points for pins and sweep the curves with a string. Make the joint through N square with N T; dress to the lines and the mould is complete for lower part of wreath piece. The stuff being cut square through, and joints made, the bevels are applied, as shown on square sections.

To find the mould for upper part of wreath. This is done by marking a right angle on a piece of board, as shown at Fig. 4. Make S N and N L equal corresponding letters shown on elevation (to the right). Here observe that the straight wood from L falls level, but the plank being thrown on the pitch S N at the elevation

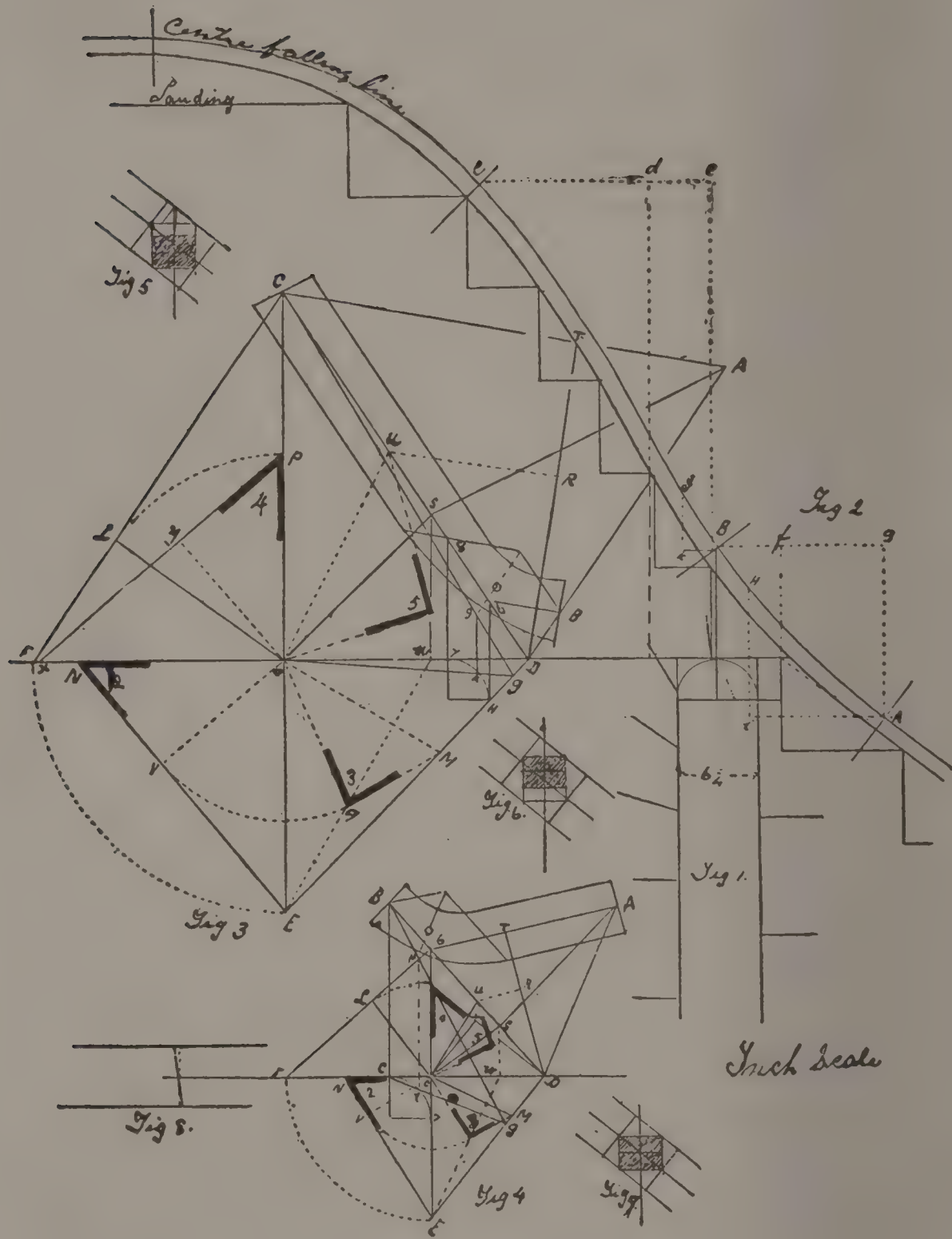
makes the straight part of mould wider than it is at joint S, which is just the width of rail. This matter, however, is regulated by bevel X. Further observe that when the wreath pieces are bolted together, see that the square line through joint S at Fig. 4, and the line made by bevel W, at Fig. 3, comes exactly opposite. This will cause the wreath to stand in its true position over the plan of stairs; in a word, finish everything on the bench ready for fixing. This shows the necessity of being accurate in both drawing and working. Here the plan is laid down to a large scale; the meaning and intention of every line is clearly shown; there is nothing hidden or concealed to confuse or perplex any one of ordinary ability.

It is understood that this drawing answers equally well for starting from a level as it does for landing. In either case have the face of riser on a line with center of rail at L.

STAIR HAVING A SMALL WELL HOLE

Example 20.

In this example the well is very small, being only $6\frac{1}{4}$ inches from center to center of rail. The first quarter space is a landing; the second quarter space commences with four winders spread up the string, with one square step to another landing. Fig. 1 is the plan (over which I had no control) showing the position of risers on center line of rail. Fig. 2 is the elevation of steps and risers, being a development of center line of rail on plan. Draw the curved line over nosings as shown; half the depth of rail and parallel to curved line, draw center falling line of rail; make joints square with center line (which will be true butt joints). Heights of wreathed pieces are shown by the dotted lines. Notice, in the top wreath, at

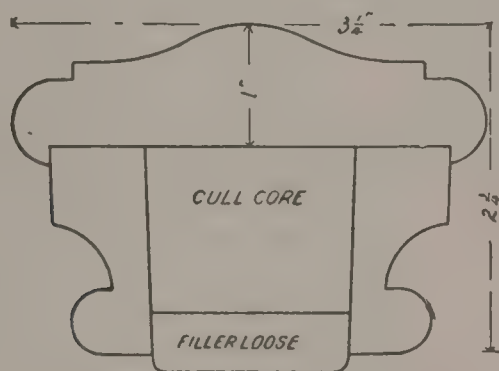


Example 20.

the joints, there is a deviation between the center of rail and the center of plank, for the purpose of bringing center of plank as near center of rail as possible throughout in order to save stuff. In the face-moulds I use tangents, but I make them conform to the rail, and they assist in the construction of the figures. Let us take the face-mould for top wreath first. In Fig. 3 let $O 7 K H$ be the plan of center line of rail for top wreath between points B and C , Fig. 2, making $O 7$ equal $c d$, Fig. 2 (when I mention two letters, I mean the line between them). From O and K rise perpendiculars to $F D$; make $O c$ equal $B e$, Fig. 2, and $K j$ equal $K j$, Fig. 2. Draw from c through j , and from O , through R , until they intersect in g . Now, from H through g draw to D . This line is the horizontal trace of the plane of plank. Join $C D$, which is the top tangent. From H and 7 rise perpendiculars to $F D$ until they meet $C D$ in 8 and 6 . Now extend $C O$ and $D H$ to meet each other in E . Make $O F$ equal to $O E$, and join $C F$. This line is parallel to bottom tangent. Now make $C A$ equal $C F$, and $D A$ equal $D E$; $D E$ is also the horizontal trace, and $D A C$ is the oblique triangle. Now make $D B$ equal $D H$ and join $6 B$; this is the lower or bottom tangent. The bevels are the next consideration, and on this subject permit me to say they are obtained on planes parallel to their respective joint planes. They can be found in various ways, and nearly anywhere on the drawing, if the inclination of the point in elevation is drawn to a line parallel to the tangent from the joint on the face-mould. Let us find the bevels for top joint, C , first. Take the inclination of joint C , Fig. 2, and place it in Fig. 3 as $O S$. Draw from S to A . This line is the direction of joint C on the face-mould; hence, draw joint C parallel to it. Now,

make OM equal OS , and join NE , and bevel 2 is the twist bevel for joint C . The bevel over the end of the joint is the next consideration. It must be applied from the top surface of the plank downwards, at right angles to the edge of the joint both ways. To find it, from O draw a line square to NE , as OV and from S drop a line square to FD as SW ; join WE . This line is the horizontal projection of the intersection of a plane parallel to joint plane and the plane of plank. Draw a line from O square to WE , meeting DE in M . Now, with O as center, with OV as radius, describe an arc to cut WE in 9 ; join $O9$ and $M9$ and bevel 3 is the bevel for over the end of the joint, C . To find the bevels for the lower joint B : Now, as CF , when in position, is parallel to the lower tangent, and, therefore forms a similar vertical triangle to the lower tangent, it is correct to use it. Besides, it gives no longer lines for bevels, and presents confusion by having lines on top of one another. Therefore, let us take the inclination of joint B , Fig. 2, and place it in Fig. 3 as OL . Now with O as center and OL as radius describe an arc, cutting OC in P . Make OX equal OD , and join XP and bevel 4 is the twist bevel for joint B . Make CT equal CL ; join TD . This line is the direction of joint B upon the face-mould. Hence, make joint B on face-mould parallel to it. To find the bevel over the end of joint B to be applied from the top surface of the plank downwards, and at right angles to the arris of the joint both ways. From O draw a line square to XP as OY . Make TR equal PY . From R square a line to meet CD in U . Now join UO . Now make $U5$ equal UR and $O5$ equal OY , and the bevel 5 is the bevel required. All these lines and bevels are exceedingly simple to anyone who understands solid geometry.

Fig. 5 shows a square section of rail at joint C, with thickness of plank sufficient to make a square section throughout the wreath; but this thickness can be reduced according to moulded section of rail. Fig. 6 shows the section of top wreath at joint B. These sections show the width of face-mould at each end. The face-mould and bevels for the lower wreath are shown at Fig. 4. In this case the center falling line of rail and the center line of plank nearly coincide throughout; hence the plank is made to rest on points B, H and A, Fig. 2. The construction



BUILT-UP STAIR RAIL.

of face-mould and bevels is exactly the same as Fig. 3. The lettering is also as far as possible the same, therefore it will be unnecessary to further explain them. Fig. 7 shows the section, taken with the most acute twist bevel, giving thickness of plank for a square wreath. The face-moulds are the proper length in the center of plank; but if the bevel over the end be acute, a piece must be added to the length of face-mould, at C. This is seen at Fig. 8. The down bevel for each end must be used to get the proper length to add to or take from the length of face-mould, as the case may be. Apply the bevel through the thickness of stuff and square up from the center and the proper length will be found.

HANDRAILING AND STAIR BUILDING.

QUESTIONS.

1. For what purposes are stairs constructed?
2. What are the essential features that a stair and its adjuncts should possess?
3. Give sketches of eleven different styles of stairs and descriptions of same.
4. Give a description of the method for obtaining the face moulds and bevels of turnout and wreath pieces of a straight stair with an ordinary cylinder at the top, provided for a return rail on the landing.
5. Give a description of the method of obtaining the face moulds of a stair with a landing and return steps.
6. Give description and drawings which show the application of the spring bevels and templets for squaring the wreaths.

COMMON-SENSE HANDRAILING

7. Give description and drawing how to obtain spring bevels.

8. Give descriptions and drawing how to obtain bevels for joints connecting with straight rail.

9. Give description and drawing how to form a rail to suit a stair with an acute angular landing and cylinder.

10. Give a drawing showing the application of bevel to wreath.

11. Give description and drawing of the method for constructing the face moulds of a handrailing for a stair having a half-turn with two risers on landing.

12. Give description and drawings of how to produce the face moulds, bevels, etc., for a quarter-space stair with four winders.

13. Give description and drawings of the method of drawing moulds for a quarter-space stair having seven winders.

14. Give description and drawings representing a flight of stairs with four winders, quarter landing, and return flyers.

15. Give descriptions and drawings representing a flight of stairs having seven winders forming a half circle, with flyers above and below.

16. Give description and drawings which show a method of laying down the rail for a flight of circular stairs.

17. Give a description of the proportions to be used in making the risers and treads of a stair which is easy and comfortable to walk up.

18. Give a "rough and ready rule" for the usual sizes of treads and risers for stairs.

19. Give a description of how staircases should be

QUESTIONS

placed in buildings, and the characteristic features which all staircases should have.

20. Give diagrams which show a stair with six flyers and six winders, with instructions to lay out and set up the strings.

21. Give description and diagram showing an easy way of getting out stair rails over cylinders.

22. Give diagrams and description of how to obtain a wreath for half-space landing.

23. Give diagrams and description of how to square the wreaths.

24. Give diagrams and description of how to obtain a wreath for a quarter-space landing.

25. Wherein consists the chief difficulty in the construction of handrails, and in what kind of rail more particularly?

26. Give a diagram and description showing the plan of a rail for a level landing stair with the risers landing and starting in the springing, the radius of the center line of rail half the width of tread.

27. Show diagram of the figure that represents the wreath worked into cylindrical form and ready for squaring, and the shaded portions that show the slabs that have to come off.

28. Give sketch and description that shows a better wreath than the previous one (No. 27).

29. Give sketch and description that shows the wreath piece cut out and worked into cylindrical form ready for squaring, the face mould being applied the same as in No. 27.

30. Give sketch and description that shows the face mould for a large well with the risers in the springing.

31. Give sketch and description of a quadrant which

COMMON-SENSE HANDRAILING

is the center line of rail, also the two tangent lines, and the other two the springing lines, which are at right angles to the tangent lines, and meeting in the center, where the center line of rail is drawn, thus showing the plan of a square prism, and the other lines that may be obtained in this problem.

32. Give a sketch showing a perspective view of the prism in order to obtain the necessary bevels, that is, the angles the cutting plane makes with the vertical faces of the prism.

33. Give a diagram which shows the tangent making an obtuse angle.

34. Give sketch and description which shows the tangent making an acute angle, the construction and lettering being the same as No. 31, with the exception that both bevels are found on one horizontal plane.

35. Give a sketch of the block shown in plan of last problem, No. 34, which represents more clearly how the bevel for the lower pitch is obtained.

36. Give the plan of a rail for a level landing, the risers landing and starting in the springing of the well.

37. Give a sketch which shows the face mould, the square being drawn the same as in last problem (No. 36); and having drawn the center line, describe how to determine the horizontal trace or directing ordinate, for all ordinates must be parallel to this line.

38. Give a sketch and description which shows the wreath cut out square through the plank, planed true, and the mould applied, the tangent lines pricked off and the joints marked.

39. Give a sketch which shows the face mould in position with the tangent lines held to the corresponding

QUESTIONS

line on the wreath, the etched part showing the amount to be taken off.

40. Give a sketch and description that shows the plan of a rail for a quarter-space landing, the risers landing and starting being placed in the springing of the well.

41. Give a sketch showing how the wreath is worked into cylindrical form and the lines ready for squaring, also a description of how to draw the lines on the stuff and in squaring the wreath.

42. Give a sketch and description of the plan and stretch-out of the tangents for another quarter-space landing being struck with a smaller radius than in sketch of problem No. 26.

43. Give a sketch and description showing how the usual thickness allowed for the wreath is obtained.

44. Give a sketch and description showing the plan of center line of rail for a well with six winders, two of them being in the springing at each side.

45. Give a sketch and description showing how the stretchout or development of the tangent lines is obtained.

46. Give a sketch and description showing how to obtain the face mould for the lower portion, the drawing being similar in every respect to what has already been described in last problem, No. 45.

47. Give a sketch and description showing the face mould for the top portion.

48. Give a sketch and description which shows a simple method of finding bevels, and one which answers in every case.

49. Give a sketch of the plan of the wreath, showing the risers and tangents.

50. Give an isometrical sketch of the wreath worked

COMMON-SENSE HANDRAILING

into cylindrical form, and description of how this is done.

51. Give a sketch showing the development for the wreath to be in one piece with the casing on the straight line at the top.

52. Give a sketch and description showing the development for the wreath to be in two pieces.

53. Give a sketch and description showing the face mould.

54. Give a sketch and description showing the bevels.

55. Give a sketch and description showing the plan and development of the center line of a rail for a well with two quarter-space landings, the risers being placed in the springing at each side of the well.

56. Give a sketch which shows an isometric projection of the cylinder with the lines on the surface.

57. Give a sketch which shows the face mold in its position when held to the tangent lines, and is known as the square cut.

58. Give a sketch and description which shows the mould marked on top and bottom faces of the plank, and how the wreath is cut out, and known as the bevel cut.

59. Give a few diagrams which show several sections of handrails.

60. Give a description of newelled or platform stairs and some of the characteristic features in their construction.

61. What is essential in the construction of every flight of stairs, so that it may not be difficult nor dangerous in ascent?

62. Give a description of the proper proportions that should be adopted in the construction of the risers and treads.

QUESTIONS

63. Give a description of the different materials of which stairs may be constructed.
64. Give a description of how stone or marble stairs are erected and supported.
65. Give a description of the sizes and thicknesses of "strings" necessary for flights of stairs having ten or less treads.
66. Give a description of the construction of a stair platform built on posts.
67. Give a sketch and description of the ground plan of an open newel stair having two landings and closed strings.
68. Give a sketch and description showing the elevation in full with a story rod on the right, and the number of risers spaced off, also design of newel, spandrel, framing, paneling, and "raking" balusters.
69. Give sketches and description showing the end of the bottom step, which is semi-circular or "bull-nosed," also an end view of the lower tread and riser with the shank of the newel passing through.
70. Give a sketch and description of the manipulation of the cap at the top of the newel, where the rail finishes sometimes in landing stairs.
71. Give a sketch and description showing how to cut the miter on the cap.
72. Give a sketch and description illustrating the construction of the "pitch board."
73. Give a sketch and description showing the manner of "housing" where the treads and risers are in position, secured in place by means of wedges.
74. Give a sketch and description showing a housed string between newels.
75. Give sketches and descriptions illustrating two

COMMON-SENSE HANDRAILING

methods of arranging strings and carriages and adjusting ends against trimmers.

76. Give a sketch and description that shows an example of a cut and miter string, with a portion of a tread, the end of which is mitered for return nosing, and dovetailed to receive ends of balusters.

77. Give a sketch and description showing a portion of a "string" partly finished.

78. Give a sketch and description showing an end portion of a cut and mitered "string" with a part of string removed.

79. Give a sketch and description which shows the position of the string, bracket, riser and tread.

80. Give illustrations and description which explains the manner of doweling the nosing.

81. Give sketch and description of a very good method, though rather costly, of connecting tread, riser and cove, where the cove is glued into a groove made in the tread.

82. Give a sketch and description which shows the usual method of building a step.

83. Give a sketch and description which shows a quick method of making the ends of the treads for the dovetails for balusters.

84. Give a sketch and description showing a good method of fixing balusters before the rail is put on.

85. Give a sketch and description showing how the difficulty is dealt with where the bottom tread of a stair takes a quarter turn and finishes against the base of the newel post.

86. Give a sketch of the elevation of the finished step where the rounded tread and riser are seen returned against the newel post base.

QUESTIONS

87. Give a sketch plan of a portion of stair which shows the string receiving the treads and return nosings.

88. Give an illustration that represents a portion of a flight of stairs having cut strings on each side, and showing also the treads and risers.

89. Give an example and rule how to find the "rise" when the "going" is known.

90. Give the rule how to find the "going" when the "rise" is known.

91. When the total rise of the stair is known (which show by sketch of the story rod), and the approximate rise of the step is given, state how the exact rise is obtained by calculation.

92. Give sketch showing a plan of a stair having two landings and a circular-ended step, with dotted lines showing trimmer timbers.

93. Give sketch showing another plan with the order of going reversed, and with the flight between the landings having a less number of steps.

94. Give sketch showing a plan of stairs with five landings, the first step being situated in the center.

95. Give sketch of a similar stair with three landings.

96. Give sketch showing a stair with three landings and two starting flights leading to a wide flight above.

97. Give sketch showing a flight with two landings and having but one starting point.

98. Give sketch of the plan of a stair in a house, which shows an ordinary flight with landing at the top.

99. Give another sketch of the plan of a stair which shows a flight having two landings.

100. Give another sketch of the plan of a stair something like the last, only reversed, and lighted by a window on the top landing.

COMMON-SENSE HANDRAILING

101. Give a description regarding the height that a rail should be from the tread.

102. Give a description of how to proceed in planning and designing stairs.

103. Give a sketch of a stair taken from an English example of the Georgian period, and a description of the rail, newel risers and treads, also its general characteristics.

104. Give sketch of spiral balusters, with rail, newel, string and drop, and description of same.

105. Give a few examples of chamfers and stops for corners of newel posts.

106. Give an illustration and description of the method of obtaining a reduced pattern for a bracket as required for the ends of winders.

107. Give eight illustrations which give brackets and sections of handrails of various kinds.

108. Give meaning of the term "axis" in "architecture," in "geometry," in mechanics, and in "turning," respectively.

109. What is meant by the term "baluster" in the construction of a stair?

110. What is meant by the term "balustrade?"

111. What is meant by the term "butt joint?"

112. What is meant by the term "cockle stairs?"

113. What is meant by the term "circular stairs?"

114. What is meant by the term "curve out?"

115. What is meant by the term "curtail step?"

116. Give a description of the term "cylinder" used in geometry.

117. Give a description of what is termed "a prism."

118. Give a description of the term "cylinder," so-called by joiners.

QUESTIONS

119. Give a description of the term "dog-legged stairs."
120. Give a description of what is meant by "elliptic stairs."
121. Give the meaning of the term "face mould."
122. Give a description of what is meant by a "flight of stairs."
123. Give a description of what is meant by "front string."
124. Give a description of what is meant by "fillet."
125. Give a description of what is meant by the term "flyers."
126. Give a description of what is meant by the term "geometrical stairs."
127. Give a description of the term "half-space."
128. Give a description of the term "handrail."
129. Give a description of what is meant by the term "hollow newel."
130. Give a description of what is meant by the term "helix."
131. Give a description of what is meant by the term "housing."
132. Give a description of what is meant by the term "kerf."
133. Give a description of the several instances in which the term "newel" may be applied.
134. Give a description of the instances in which the term "keys" may be applied.
135. Give a description of what is meant by the term "nosing."
136. Give a description of what is meant by the term "pitching piece."

COMMON-SENSE HANDRAILING

137. Give a description of what is meant by the term "pitch."

138. Give a description of what is meant by the term "pitch-board."

139. Give a description of what is meant by the term "ramp."

140. Give a description of what is meant by the term "scroll."

141. Give a description of what is meant by the term "splay."

142. Give a description of what is meant by the "spring bevel of a rail."

143. Give a description of what is meant by the term "squaring a handrail."

144. Give a description of what is meant by the term "spiral" in "geometry" and in "architecture."

145. Give a description of what is meant by the term "spandril."

146. Give a description of what is meant by the term "string-board."

147. Give a description of what is meant by a "well staircase."

148. Give a description of what is meant by the term "tread."

149. Give a description of the term "winders."

150. Give a description of what is meant by the term "wreath."

151. Describe a stair having flyers and winders around a half-space without cylinder.

152. Show by diagram a method of laying out a handrail for a quarter-space continued stair.

153. How would you lay out a "wreath" for a half-

QUESTIONS.

space stair with landing, risers being placed on spring lines.

154. Describe what is meant by a spiral stairway.

155. Show how a wreath is obtained for the rail over a spiral stairs.

156. Give a sketch or two of the methods of laying out a wreath for a rail over a half-space cylinder stair.

157. Describe the method of obtaining the proper shape of ornamental "brackets" for cylindrical stairs.

158. Explain how a rail may be properly constructed over a stair having less than either a semi-circular or a quadrant.

159. Make diagram for two or three methods of laying out wreaths for quarter space continued rails.

160. Submit a diagram showing a section of a "built-up rail."

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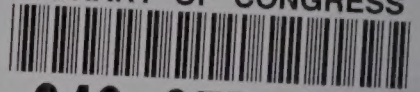
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